COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CHAPTER "E"—GENERAL DESCRIPTION

WALTER J. FRANCIS, C. E.
CONSULTING ENGINEER

CHAPTER "E".

GENERAL DESCRIPTION.

INDEX TO CHAPTER "E".

(In Index)

Subject. Page.

Subject.	Page.

LIST OF ILLUSTRATIONS.

LIST OF ILLUSTRATIONS.

LIST OF ILLUSTRATIONS.

[illegible]

[illegible]

[illegible]

LIST OF ILLUSTRATIONS.

Chapter E.

GENERAL DESCRIPTION.

In addition to the right-of-way and crossings, which may be considered as common to the whole project, the Queenston-Chippawa Power Development consists of seven principal elements working in proper co-relation to provide the means of converting the potential energy of the water of the Niagara River into electrical energy. The seven elements may be briefly described as,-

(a), the Intake, through which water is diverted from the Niagara River into the Welland River;

(b), the Welland River, where the improved river channel is utilized for the passage of the water;

(c), the Canal, which conveys the water from the Welland River, to the forebay near the Power House;

(d), the Forebay, where the water is spread out or distributed over a relatively wide area;

(e), the Screen House, where the water is diverted into various channels leading therefrom;

(f), the Penstocks, being the steel tubes or pipes carrying the water from

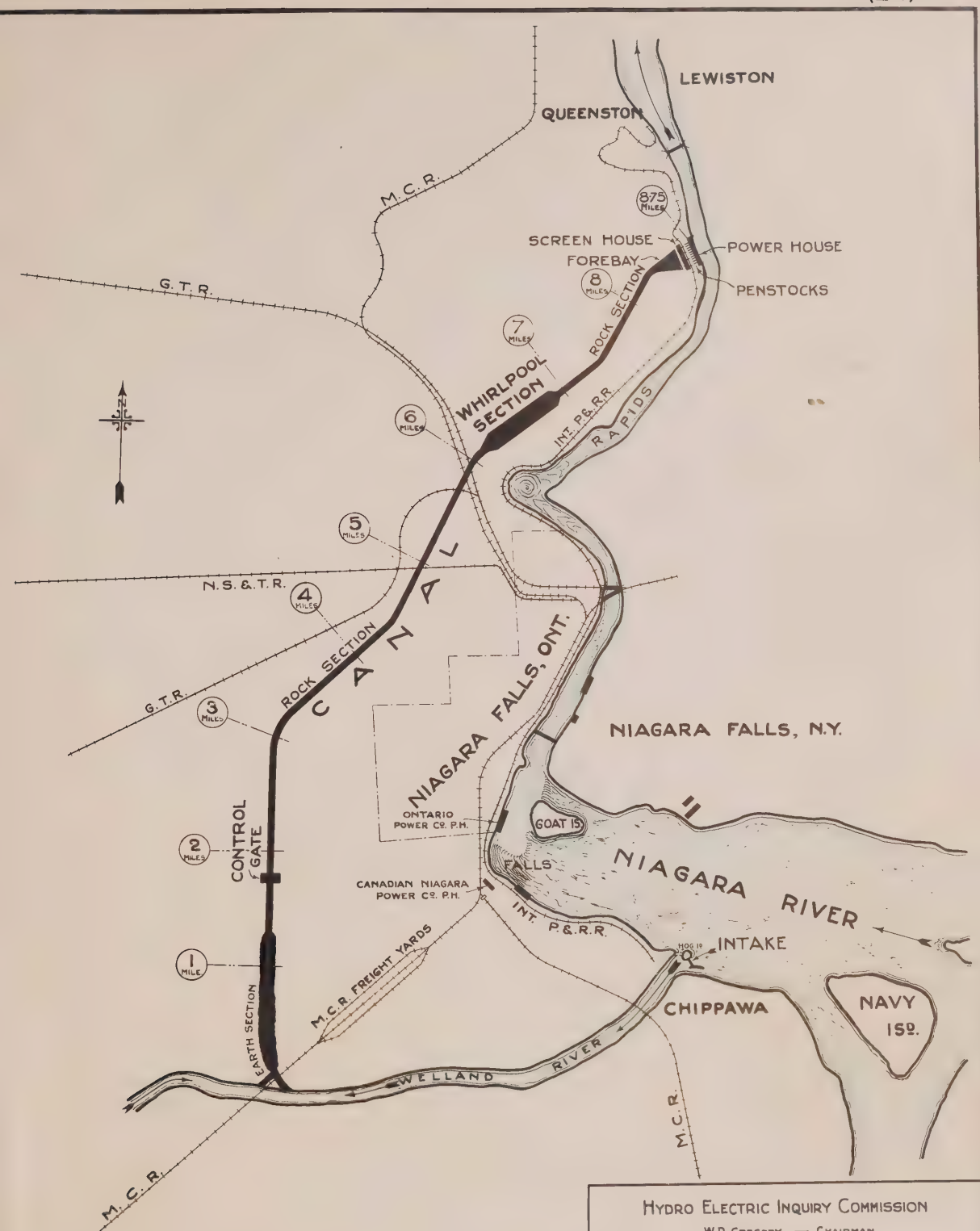
the Screen House over the cliff down to the turbines; and

(g), the Power House, in which are located the turbines and the generators for converting the hydraulic energy into electrical energy.

The general location of the various elements of the development with regard to the adjacent country is shown on the "Plan of Vicinity" included as page E-3. The right-of-way and crossings will be dealt with at the conclusion of this Chapter.

The Intake.

The Intake is situated at the mouth of the Welland River, sometimes referred to as Chippawa Creek, adjacent to the Village of Chippawa, about two miles above the Falls of Niagara. The Niagara River at this point has a width of about one and one-quarter miles, and the mouth of the Welland River is at the inner end of a wide bay, and is divided into two channels by Hog Island. Close to the opposite (New York) shore of the river, there is a small island, known as Grass Island, hence the reference to this section of the Niagara River as the Chippawa-Grass Island Pool. The general location of the Intake with regard to the neighbouring parts of the Province of Ontario, and to the State of New York, and also with regard to Lake Erie and Lake Ontario, is indicated on the "Map Showing Location of Development", included as page E-4, and the details of the Niagara River, in the vicinity of the Intake are shown on the plan "Location of Intake", included as page E-5. An aeroplane view of the mouth of the



HYDRO ELECTRIC INQUIRY COMMISSION

W.D. GREGORY, — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PLAN OF VICINITY

Scale of Miles

Toronto, May 16th, 1922 Made by C.M.D. Checked by

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER.

HYDRO-ELECTRIC INQUIRY COMMISSION

W.D. GREGORY. — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MAP SHOWING LOCATION OF DEVELOPMENT

0 ½ 1 2 3 4

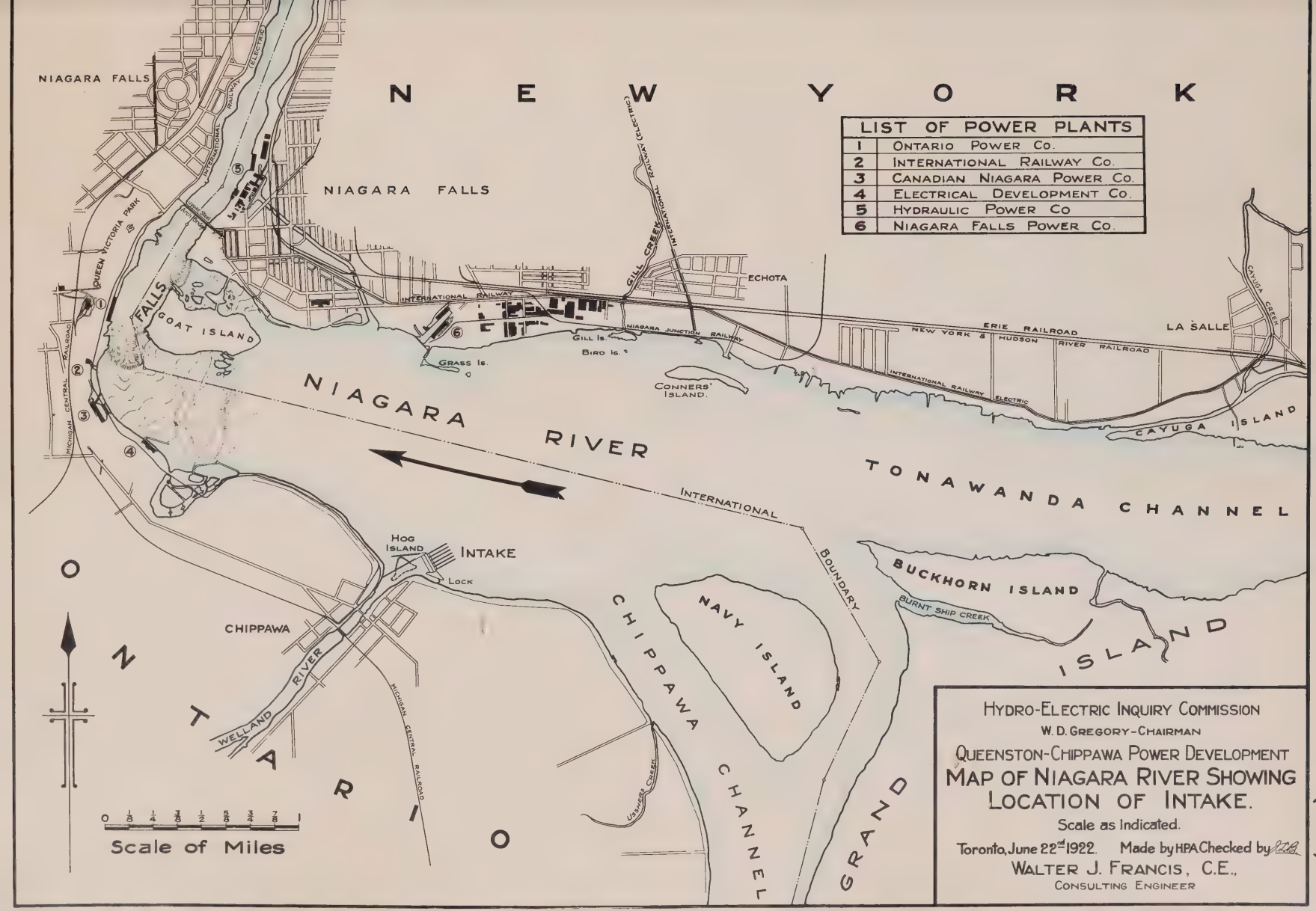
Scale of Miles.

Toronto, May 24th, 1922. Made by C.M.D. Checked by J.D.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER.

(E-4)


NIAGARA FALLS
N E W Y O R K
NIAGARA FALLS
LIST OF POWER PLANTS
1 ONTARIO POWER CO.
2 INTERNATIONAL RAILWAY CO.
3 CANADIAN NIAGARA POWER CO.
4 ELECTRICAL DEVELOPMENT CO.
5 HYDRAULIC POWER CO
6 NIAGARA FALLS POWER CO.
QUEEN VICTORIA PARK
FALLS
GOAT ISLAND
MICHIGAN CENTRAL RAILROAD
INTERNATIONAL RAILWAY
GILL CREEK
ECHOTA
GILL IS.
BIRD IS.
GRASS IS.
NIAGARA JUNCTION RAILWAY
NEW YORK & ERIE RAILROAD
HUDSON RIVER RAILROAD
LA SALLE
CAYUGA CREEK
CONNERS' ISLAND.
INTERNATIONAL RAILWAY ELECTRIC
CAYUGA ISLAND
NIAGARA RIVER
TONAWANDA CHANNEL
INTERNATIONAL BOUNDARY
HOG ISLAND
INTAKE
LOCK
BUCKHORN ISLAND
BURNT SHIP CREEK
ISLAND
CHIPPAWA
WELLAND RIVER
MICHIGAN CENTRAL RAILROAD
NAVY ISLAND
CHIPPAWA CHANNEL
GRAND
LUNDY'S CREEK
ONTARIO
Scale of Miles
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY - CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
MAP OF NIAGARA RIVER SHOWING LOCATION OF INTAKE.
Scale as Indicated.
Toronto, June 22nd 1922. Made by HPA Checked by
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

(E-5)

To face page E-6.

No. E-1

Photograph showing

General View of Intake Excavation Work.

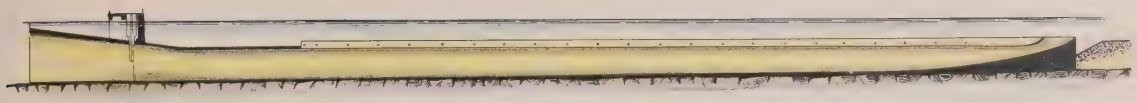
looking westerly along Welland River from aeroplane.

Taken September 23rd, 1921.

Welland River, taken during the construction of the Intake, is included as page E-6.

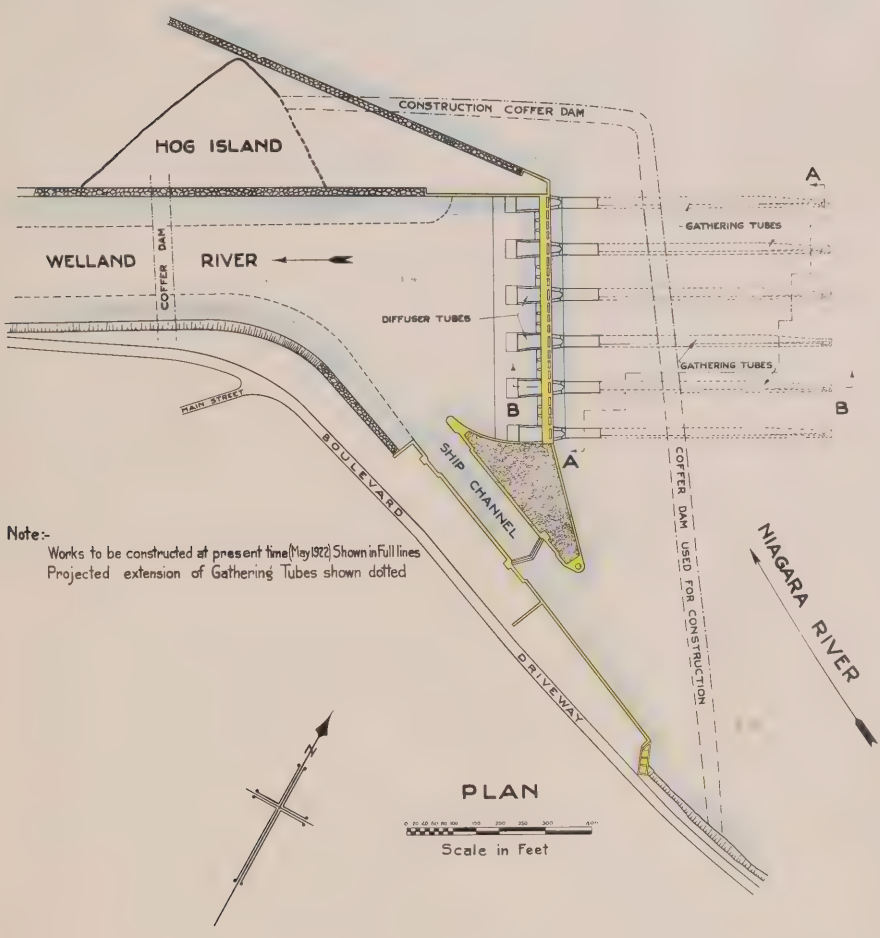
During the years 1918 and 1919 intensive studies were made by the engineers of the Hydro-Electric Power Commission in order to determine the best form of intake structure to meet the peculiar and varying conditions that might be expected to obtain from time to time. These studies were carried out not only theoretically but also by means of experimental models built in the Dufferin Islands Channel of the Niagara River to a scale of one-twentieth full size. In addition, as referred to in detail in the chapter entitled "Advisory Reports", the Hydro-Electric Power Commission obtained the advice of consulting engineers in private practice, who also made special studies. The problem which confronted the engineers was the designing of an intake structure which would divert water from the channel of the Niagara River into that of the Welland River with minimum hydraulic losses, and at the same time act as a barrier to prevent the passage of ice from the Niagara River into the proposed Canal. Finally, a design devised in collaboration with the engineers of the Hydro-Electric Power Commission by H. D. Johnson, consulting hydraulic engineer, New York, was adopted, but the present plans of the Hydro-Electric Power Commission provide only for the construction of a portion of the structure.

A plan showing the present and possible future construction entitled "Intake, Plan and Sections", is included herewith as page E-8. The structure is located on the south-easterly channel of the Welland River, which has been considerably widened by the removal of part of Hog Island. When the Intake will have been completed, the north-westerly channel, on the opposite



SECTION B-B

Scale in Feet



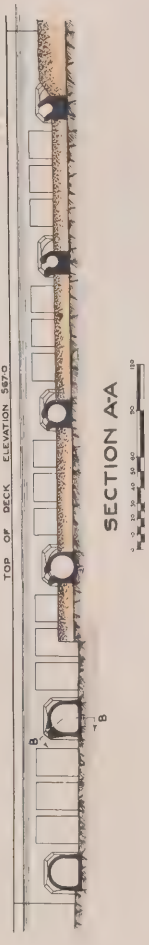
Note:-

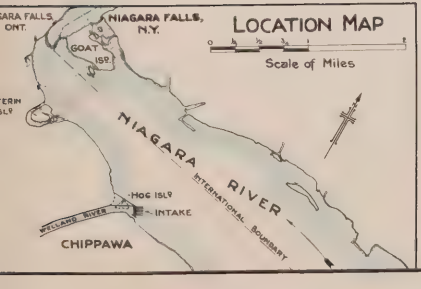
Works to be constructed at present time (May 1922) Shown in Full lines

Projected extension of Gathering Tubes shown dotted

PLAN

Scale in Feet





HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

INTAKE, PLAN & SECTIONS

Scales As Indicated

Toronto, June 6th, 1922 Made by C.M.D. Checked by W.C.B.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

side of Hog Island will be dammed by means of an earth fill.

The Intake as adopted, consists essentially of two parts; first, a simple culvert opening which may be used for the greater part of the time, and second, a series of special subsidiary gathering tubes, which may be used to collect water free from ice during such time as that part of the river is ice-laden.

The first part of the Intake consists of a series of five groups of piers, each of which groups provides three openings each with a clear waterway 18 feet wide by 26 feet high, thus giving a total area of opening of 7,800 square feet. The top of each of the openings is eight feet below the water level so as to deflect substances floating on the water. In addition, adjustable drop gates will permit the submergence to be increased to any desired depth. The second part consists of six "gathering tubes" located 100 feet apart, spaced between and on either side of the groups of openings referred to above, and inclined upstream at an angle of about forty-five degrees with the Niagara River. As shown on the drawing on page E-6, the gathering tubes are 675 feet in length, and for the outer 500 feet are provided with a slot on the upstream side through which they collect water from near the bed of the river. The gathering tubes are to be of concrete with a circular section. At the inner end, each gathering tube changes its section somewhat, forming a "diffuser" passing through the structure containing the culvert openings, and providing a means of spreading the water into the river channel. The present plans, however, do not provide for the construction of the gathering tubes, but only for the diffusers and the pier structure.

At the shore or south-easterly end of the main Intake there is to be constructed, at the request of the Dominion Government, a concrete lock, 80 feet in

width, in order to accommodate navigation in the Welland River. At the opposite or north-westerly end, the intake structure is connected by means of a concrete wing-wall and earth fill to the Niagara River side of Hog Island.

Inland from the intake structure, the sides of the Welland River are to be finished with slopes of two horizontal to one vertical, covered with rip-rap, and a gradual transition made to the standard improved section of the Welland River channel, 150 feet in width at the bottom.

The photographs on page E-11 show the temporary dam enclosing the Intake, and the excavation methods employed prior to the letting of the present contract.

The Welland River.

Prior to the construction of the power development, the natural flow of the Welland River was in an easterly direction from Montrose to Chippawa. The slope of the River, however, was so slight that no difficulty was encountered in reversing the direction of flow by withdrawing water at Montrose through the Canal, thus taking Niagara River water through the Welland River channel from Chippawa to Montrose. The natural flow of the Welland River from the watershed west of Montrose, also passes into the Canal through a westerly channel at the south end of the earth section of the Canal.

That portion of the Welland River between Chippawa and Montrose had not sufficient capacity to take care of the required flow without serious hydraulic

To face page E-11

No. E-2

Photograph showing

Temporary Dam and Intake Excavation.

looking northerly.

Taken July 19th, 1921

No. E-3

Photograph showing

Temporary Dam, and Intake Excavation.

looking easterly.

Taken July 19th, 1921

losses, and the bed of the river was therefore dredged to a width of 160 feet, with side slopes of two horizontal to one vertical, the alignment at bends being improved where necessary. The excavation was carried down to Elevation 552.8 at the Intake, and Elevation 550.0 at the commencement of the Canal, with a slope of 0.000119, corresponding to 0.63 feet per mile, between these points, providing an average depth of 28 feet at low water. The total length of the improved section is 21,000 feet or nearly 4 miles. The character of the River with the spoil-banks may be clearly seen by reference to the aeroplane photograph on page E-6, already referred to.

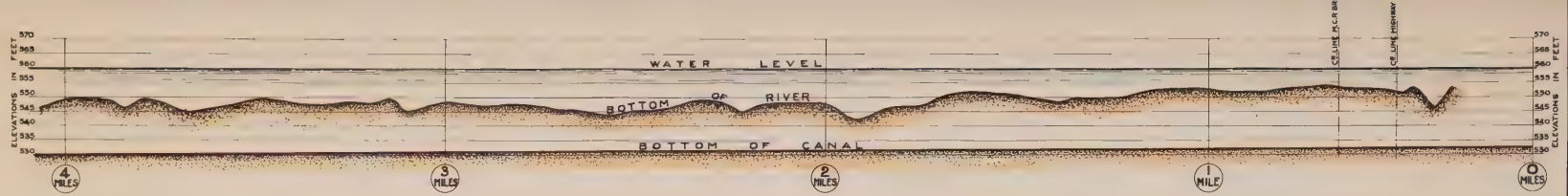
At the easterly end of the Welland River section, in the village of Chippawa, there are two bridges, namely, the Chippawa Highway, and the Michigan Central Railroad. The former of these was entirely rebuilt, while the latter was lengthened by the addition of two plate-girder spans.

The general location of this section of the River, together with the profile of the bed of the River and the excavated cross-section, is shown on the drawing included as page E-13.

The Canal.

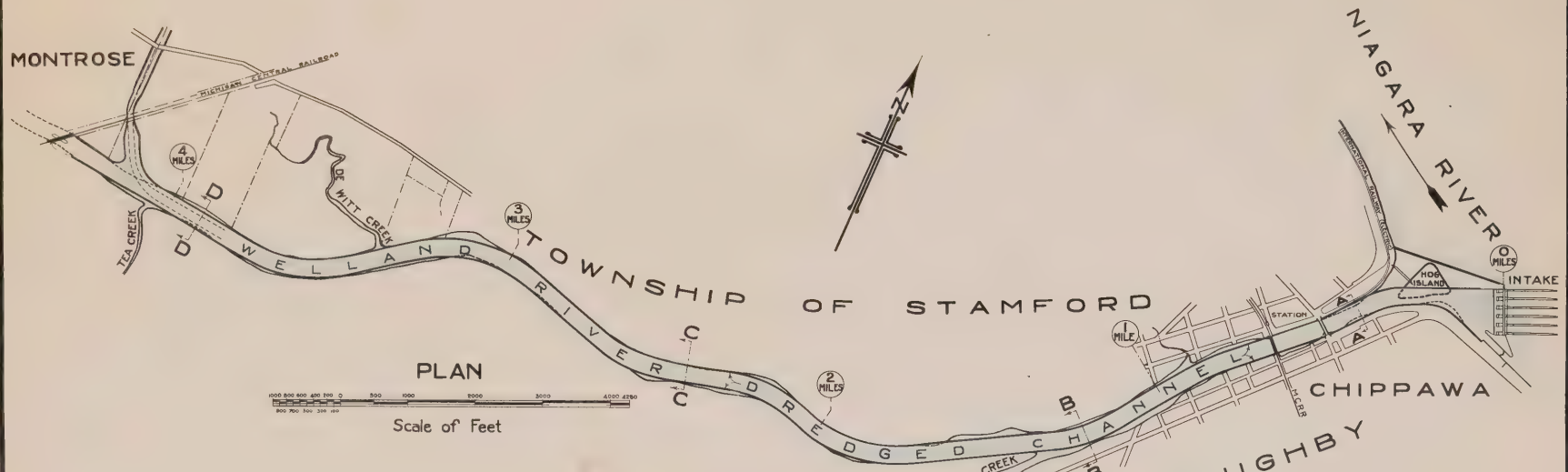
The Canal commences at a point on the Welland River near the village of Montrose and adjacent to the crossing of the Welland River by the Michigan Central Railroad, Welland-Niagara branch, about 21,000 feet from the junction of the Welland and Niagara Rivers. Thence the Canal follows a northerly di-

COPY



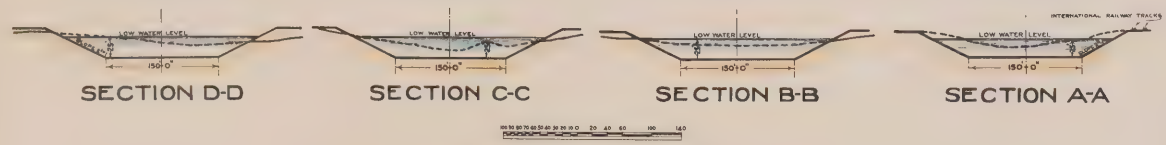
PROFILE

Scales As Indicated



PLAN

Scale of Feet



SECTION D-D SECTION C-C SECTION B-B SECTION A-A

Scale of Feet for Sections

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PLAN SHOWING EXCAVATED CHANNEL OF WELLAND RIVER

Scales As Indicated

Toronto, 28th June 1922 Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(E-13)

rection to a point about three-quarters of a mile west of Winery Road in the Township of Stamford, a distance of about 3-1/2 miles. It then turns in a north-easterly direction, crossing Winery Road and Victoria Street, again deflecting towards the north at a point in the vicinity of Portage Road. From the curve at Portage Road, the Canal follows a straight line for a distance of 1-1/2 miles to a point immediately north of the Grand Trunk and Michigan Central Railways, opposite the Niagara Whirlpool, near the south side of Bowman's Gully. Crossing the gully, the Canal follows a north-easterly direction for 1-1/2 miles, and then a northerly direction for about one mile, and finally an easterly direction for about one-quarter of a mile to the entrance of the Forebay immediately above the Screen House, below which is the Power House itself. The Power House is located on the Niagara River immediately above Smeaton's Cove, at a point about one mile above the suspension bridge at Queenston.

The general location of the Canal as described above is shown on the "Map Showing Location of Development", included herewith as page E-4, while the detail location is indicated on the "Location Plan" included herewith on page E-15. The "Location Plan" also shows the lands retained for construction purposes, and for the right-of-way adjacent to the Canal, bordered in pink. This location was determined after careful topographical surveys and studies of the contours and other natural features of the country had been made, and also after investigating the comparative economy of alternative tunnel projects. The northerly end of the Canal location was determined by placing the Power House as far south in the Niagara River as was consistent with reaching the level of Lake Ontario within practical limits.

MILES FROM JUNCTION OF CANAL AND WELLAND RIVER SHOWN THUS – (7)

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY – CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

LOCATION PLAN

600 500 0 1000 2000 3000 4000 5000

Scale of Feet

Toronto, June 17th. 1922, Made by: [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(E-15)

To face page E-16.

No. E-4

Photograph showing

Character of Country Traversed by Canal,

looking northerly along central part of Canal from aeroplane.

Taken September 23rd, 1921.

7 MILES
9 MILES
5 MILES

To face page E-17.

No. E-5

Photograph showing

Character of Country Traversed by Canal.

looking northerly along central part of Canal from aeroplane.

Taken September 23rd, 1921.

MILES 8
MILES 7
MILES 6
MILES 5

Generally speaking, the Canal passes through a country highly developed for agricultural purposes, and for fruit growing. It would not have been possible to avoid valuable territory. The general character of the country is shown on the aeroplane photographs on pages E-16 and E-17.

Provision has been made for bridges over the Canal for the majority of the highways existing prior to its construction, and for all of the railways. It is proposed to provide a total of nine highway bridges and five railway bridges.

The Canal as at present constructed, was designed for a flow of 15,000 cubic feet of water per second, but since it has been put into operation the engineers of the Hydro-Electric Power Commission have made further study of such elements of their calculations as prior to the construction of the Canal could only be theoretically determined, and have reached the conclusion that the ultimate capacity of the Canal as now built will in all probability reach 18,000 cubic feet per second.

The total length of the Canal from the intersection of its centre line with the centre line of the Welland River to the beginning of the Forebay, is 45,284 feet or 8.58 miles. For the purposes of description, it may be divided into the following sections:-

	From Station	To Station	Length
Earth Section.....	0+00	64+00	6,400 ft.
Southerly Rock Section.....	64+00	329+50	26,550 ft.
Whirlpool Section, including Transitions.....	329+50	354+00	2,450 ft.
Northerly Rock Section.....	354+00	452+84	9,884 ft.

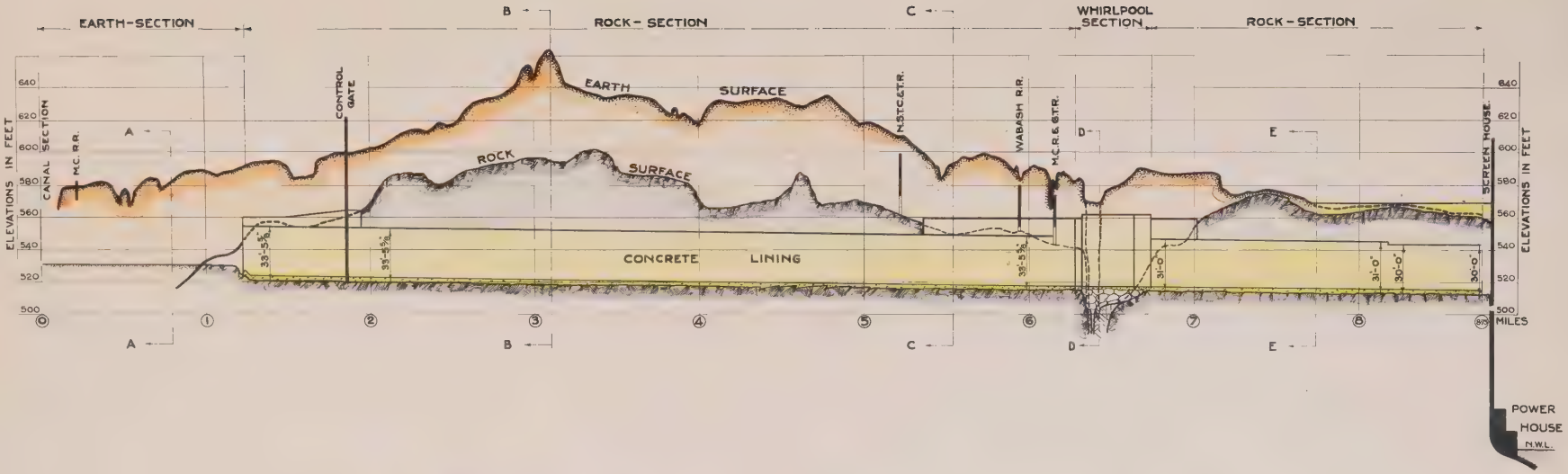
The relative locations of the various sections are shown on the "Plan of Vicinity", included as page E-8, and the location in detail is shown on the plan entitled "Location Plan" included as page E-15.

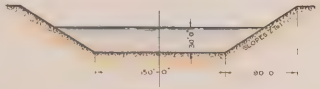
On page E-20 is included a drawing entitled "Profile and Sections of Canal", which indicates the location on the profile of the various sections, together with the earth surface, the rock surface and the extent of the concrete lining. Typical cross-sections at various points of the Canal are also shown on this drawing.

Earth Section.

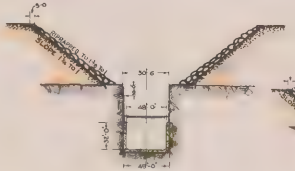
The earth section of the Canal commences at Station 0+00 on the Welland River and ends at the commencement of the concrete-lined rock section at Station 64+00, having a total length of 6,400 feet. As shown in "Section AA" of the drawing referred to above, included as page E-20, excavation has been carried out to provide a minimum width of 150 feet at the bottom of the Canal, and to a depth of 30 feet below the surface of the water. The side slopes are made at an angle of two horizontal to one vertical. The excavation was carried down to Elevation 550.0 at the southerly end, and 529.22 at the northerly, with a slope of 0.000119, or 0.63 feet per mile, between these two points. The average depth of cut is about 50 feet. The ground through which the earth section has been excavated may be described as being composed generally of blue clay.

The designs contemplate a bottom width of 240 feet through the earth section of the Canal when ultimately completed, that is, for a flow of 15,000 cubic

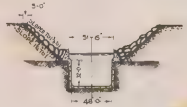




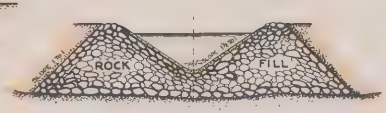
SECTION AA



SECTION BB

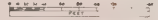


SECTION CC



SECTION DD

SECTION EE



SCALE FOR SECTIONS

EARTH SHOWN THUS:-

ROCK SHOWN THUS:-

CONCRETE SHOWN THUS:-

HYDRO-ELECTRIC INQUIRY COMMISSION
W.D. GREGORY, — CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PROFILE & SECTIONS OF CANAL

Scales As Indicated

Toronto, May 19th, 1922 Made by CWFD Checked by

WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

(E-20)

feet per second or more.

Southerly Rock Section.

The southerly rock section extends from Station 64+00 to Station 329+50, a total distance of 26,550 feet. For practically the entire length of this section the surface of the rock was considerably above the elevation determined for the water level of the Canal, and everywhere there was a deep overburden. The maximum depth of the cut is 140 feet below the ground surface and occurs in the vicinity of Lundy's Lane. The maximum depth of rock excavation was found to be 85 feet. The excavation was carried down to Elevation 522.3 at the southerly end and 516.74 at the northerly, with a slope of 0.0002113, or 1.11 feet per mile, between these two points.

Photograph E-6 indicates the character of the rock, while photograph E-7 shows the rock and the overburden in detail during construction. These pictures are included herewith as page E-22.

The bottom of the Canal was paved and the sides were lined throughout the rock section with concrete, smoothly finished, as will be seen by reference to the photograph on page E-23. The width of the rock cut on the straight portions was uniformly 50 feet, while the clear finished width from face to face of the concrete lining is 46 feet. In the curves of the Canal additional width was obtained by using a constant radius of 500 feet for the finished concrete surface on each side of the Canal. Chamnellers were used on both sides of the cut, working down from the surface a depth of ten feet or thereabouts. The design provides that the earth overlying the rock be excavated to a width sufficient

To face page E-22

No. E-6

Photograph showing

Character of Rock Cells of Canal, ready for Sealing.

looking along bottom of Canal.

Taken June 1st, 1920

COPY

No. E-7

Photograph showing

Rock-work of Canal, and overburden.

looking from top of cut.

Taken May 4th, 1921

To face page E-23

No. E-8

Photograph showing

Canal with finished concrete lining.

looking along bottom.

Taken December 22nd, 1921.

to allow a berm of 10 feet on each side of the Canal between the toe of the earth slope and the edge of the rock cut, and then sloped back on each side with slopes of one and one-quarter horizontal to one vertical, covered with riprap, with a slope of one and three-eighths horizontal to one vertical. The material overlying the rock throughout this section was found to consist of sand in the northerly half, and blue clay in the southerly part, with coarse gravel and sand immediately over the rock throughout the whole length. The rock itself is Niagara limestone of varying degrees of hardness, in many places broken up by numerous seams, but generally uniform in stratification.

Whirlpool Section.

At Bowman's Gully, opposite the Whirlpool, the natural surface of the ground dropped below the elevation of the bottom of the Canal, and the surface of the rock proved to be entirely beyond the reach of rock drills. The engineers of the Hydro-Electric Power Commission decided to fill the gully with rock spoil, and to construct the Canal in embankment.

The Whirlpool Section commences at Station 338+50, and ends at Station 348+55, thus having a length of 1,605 feet. At the south end there is a "transition" connecting the Rock Section and the Whirlpool Section, and occupying a length of 300 feet. Similarly, at the north end of the Whirlpool Section there is another "transition" from Station 348+55 to Station 354+00, a total length of 545 feet. The object of these transitions is to provide a gradual change from the square section to the trapezoidal section and vice versa, with minimum disturbance to the natural flow of the water in the Canal.

The general layout of the Whirlpool Section and "Transitions" is clearly shown on the aeroplane photograph included herewith as page E-26.

As shown in the diagram on page E-20, the cross-section of the Canal in the Whirlpool Section is 10 feet wide at the bottom, with side slopes of one and one-half horizontal to one vertical, and the Canal is built on a heavy consolidated rock fill having exterior side slopes of one horizontal to one vertical, the depth of the fill varying with the elevation of the natural ground surface to a maximum of about 100 feet. The bottom of the Canal is at Elevation 516.74 at the southerly end of the southerly transition, and 516.20 at the northerly end of the northerly transition with a uniform slope of 0.0002113, or 1.11 feet per mile, between these two points. The manner in which the embankment was prepared is shown in the two photographs included herewith as page E-27. Spoil from the Canal was deposited on either side of the rock fill with the object of increasing the stability of the fill, and also of disposing of the surplus material from the Canal, and of evening up the surface of the ground between the Canal and the Whirlpool.

The Whirlpool Section is lined with concrete throughout, with a minimum thickness of twelve inches. In order to avoid the possibility of the concrete being broken by back-pressure of water contained in the fill, in the event of the water being drained from the Canal, weep-holes are provided both near the top and near the bottom of the concrete lining. The finished work from Rock Section to Rock Section is clearly shown on the photograph included herewith as page E-28.

(2046)

To face page E-26.

No. E-9

Photograph showing
Whirlpool Section and "Transitions",
looking northerly from aeroplane.

Taken September 23rd, 1921.

(MILES)
7

To face page E-27

No. E-10

Photograph showing

Surfacing of Rock Fill in Shirlmont Section

forming foundation for concrete lining.

Taken January 8th, 1921

COPY

No. E-11

Photograph showing

Surfacing of Rock Fill in Shirlmont Section

forming foundation for concrete lining.

Taken March 4th, 1921.

To face page E-26.

No. E-12

Photograph showing
Cavulated Whirlpool Section and "Transition",
looking north-easterly from the bottom.

Taken December 23rd, 1921.

Northerly Rock Section.

The Northerly Rock Section commences at the northerly end of the Whirlpool Section transition at Station 354+00, and continues to the beginning of the Forebay at Station 452+84, having a total length of 9,884 feet. This Section is similar to the Southerly Rock Section with the exception that the depth of the overburden was very much less. The excavation was carried down to Elevation 516.20 at the southerly end, and 514.13 at the northerly, with a uniform slope of 0.0002113, or 1.11 feet per mile, between these two points.

The Control Gate.

For the purpose of regulating or of cutting off the flow of water in the Canal, a control gate of the "Stoney Sluice" type has been erected at the entrance to the Southerly Rock Section at Station 97+00. The clear span of the gate is 45 feet, and the height from sill to top is 48.6 feet, while the total lift is 54.6 feet.

The movable portion of the gate is a steel structure plated on the southerly side, rivetted and caulked. The gate slides against rollers in vertical grooves set into the concrete on either side of the Canal, and is supported by heavy steel chains with counterweights, the chains passing over drums carried on a steel superstructure. An electric motor is provided for the purpose of raising or lowering the gate.

The details of the gate and of the supporting structure are shown in the photograph included herewith as page E-30.

To face page E-30

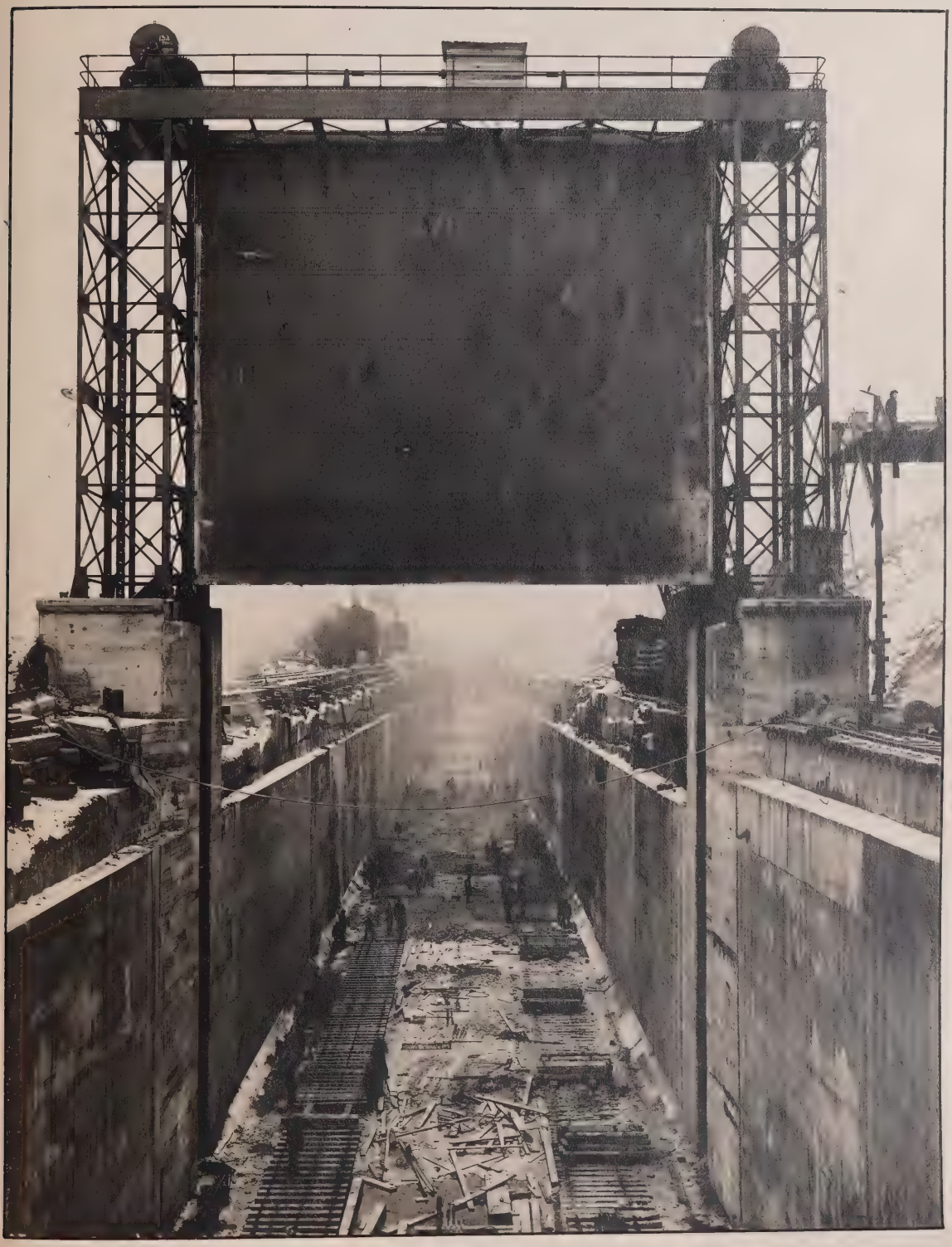
No. E-15

Photograph showing

Canal Control Gate at South End of Rock Section,

looking northerly from rock level.

Taken December 22nd, 1921.



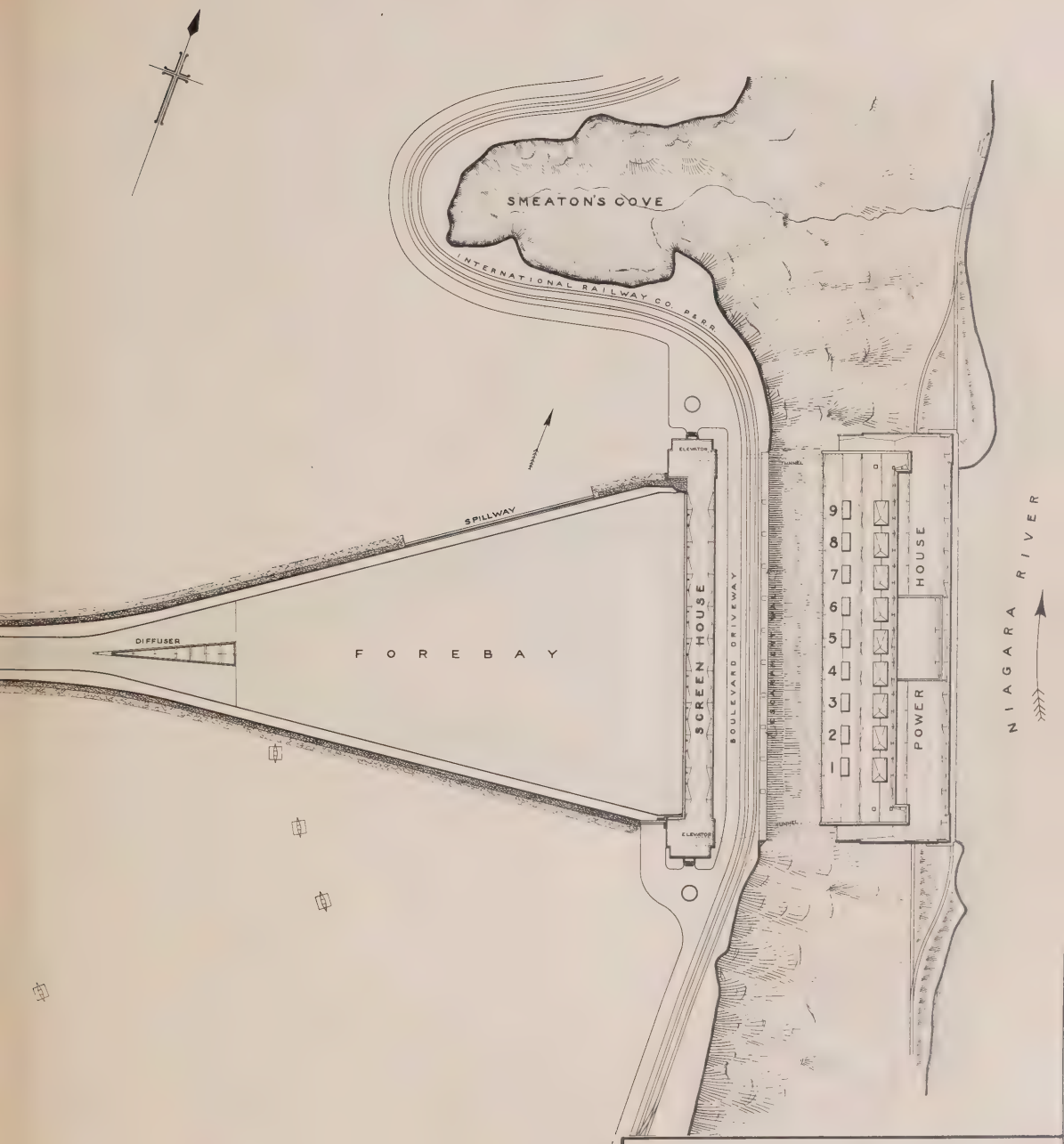
The Forebay.

The purpose of the Forebay is to provide a means of uniformly distributing the water from the Canal to the various penstocks at the Screen House, which are spread over a width of about 800 feet. The change in the flow of the water from the Canal to the Screen House has to be made in such a way as to avoid abrupt alteration in the velocity in order to decrease the loss of head which would otherwise occur. This result is obtained by gradually widening the Canal from a width of 46 feet to a width of about 800 feet at a uniform rate in a length of about 900 feet, thus forming what is referred to as the "Forebay".

As the surface of the rock at the site of the Forebay carried very little overburden and was generally below the elevation of high water, the concrete side-walls were built with the top at Elevation 570.0, about 6 feet above the maximum ordinary water level in the Forebay.

The Forebay was excavated down to about Elevation 514.0, thus providing a depth of water of about thirty feet when the plant is running at full capacity.

It can be readily understood that the water from the Canal passing into the Forebay at high velocity would tend to impinge upon the centre of the Screen House instead of being uniformly distributed to all the openings therein. In order to avoid this undesirable effect a "diffuser" has been constructed of reinforced concrete at the entrance to the Forebay, dividing the water into two channels, ensuring a more uniform velocity throughout the width of the Forebay. The diffuser has a length of 221 feet and gradually widens from a sharp prow at the upstream end to a width of 37 feet at the other.



Plan of Proposed Final Development

Scale of Feet

Hydro-Electric Inquiry Commission

W. D. Gregory - Chairman

Queenston-Chippawa Power Development

Plan of Forebay, Screen House and Power House

Scale as Indicated

Toronto, May 18th 1922 Made by H.P.A. Checked by W.J.F.

Walter J. Francis, C.E.,

Consulting Engineer

To face page E-55.

No. E-14

COPY

Photograph ~~Showing~~

Forebay Excavation with reference to Canal,

Screen House and Power House.

looking westerly from aeroplane.

Taken September 23rd, 1921.

To face page E-34

No. E-15

Photograph Showing

Completed Diffuser at Forebay.

looking along Rock Section.

Taken December 8th, 1921.

COPY

No. E-16

Photograph showing

Completed Diffuser at Forebay.

looking towards Screen House.
(about 15 feet of water in Canal)

Taken December 28th, 1921.

To face page E-35.

No. E-17

Photograph showing

Detail View of Completed Diffuser,

looking towards Screen House.

Taken September 1st, 1921.

To face page E-36.

No. E-18

Photograph showing

Breast-Wall of Forebay House and Entrance to Draft Tube,

looking south-easterly.

Taken November 17th, 1921.

The top of the diffuser is at Elevation 542.0 so as to be constantly submerged. An aperture in the end wall admits water to the interior and assures approximately equal water pressures on both sides of the walls.

The plan entitled "Plan of Forebay, Screen House and Power House", included herewith as page E-32, shows the location of the Forebay and the diffuser with regard to the adjacent Screen House and Power House. The photographs also included herewith as pages E-33 to E-36, show the salient features of the Forebay.

COPY

The Screen House.

The general location of the Screen House may be seen on the plan on page E-32.

The concrete substructure of the Screen House is 500 feet long by 56 feet wide, founded in the solid rock which was excavated to Elevation 512.0 for the purpose. The top of the substructure is at Elevation 568.0. The clear distance between the substructure and the general line of the cliff is about 60 feet. The excavation work is clearly shown in the photographs on page E-38, while the substructure itself is shown in the photograph on page E-39.

The substructure primarily provides the means of admitting water from the Forebay to the Penstocks, of which there will be ultimately ten in all, one service penstock and nine main unit penstocks, placed in order commencing after the ice chute at the southerly end of the structure.

The ice chute entrance is 25 feet wide, with the upstream sill at Elevation

To face page E-38.

No. E-19

Photograph showing

Excavation for Screen House and Pumstock Tunnels.

looking south-easterly.

Taken January 8th, 1921.

COPY

No. E-20

Photograph showing

Excavation for Screen House Foundations.

looking northerly.

Taken March 4th, 1921.

To face page E-39.

No. E-21

Photograph showing

Horsam House Substructure.

looking southerly.

Taken September 1st, 1921.

535.0, and is controlled by two sets of gates.

The service penstock entrance is 12 ft. 8 ins. wide, with the sill at Elevation 514.167, eventually leading to the mouth of the penstock which is 5 ft. 6 ins. in diameter. The entrance is sealed by a curtain wall and is controlled by a gate about 15 feet from the upstream face of the wall. Back of the gate, 6 feet therefrom at the bottom and 10 ft. 5 ins. therefrom at the top, is a screen to prevent the admission of debris.

The nine main unit penstocks are located uniformly 50 feet apart, centre to centre. Every unit has three entrances 12 ft. 8 ins. wide, with the sills in all cases at Elevation 514.167. The elevation of the lower face of the curtain wall sealing the opening is Elevation 542.07, which gives a depth of water of 28 feet. The main piers between the units are 6 feet wide, while the secondary piers in the tripartite entrances are 3 feet in width, as may be seen by reference to the photograph on page E-36. The details are shown more clearly on photograph No. E-22, included herewith as page E-41, while the lower picture, No. E-23, on the same page, shows how the concrete bell-mouth was formed so as to lead the water smoothly from the tripartite entrance to the circular penstock tube. Every opening is controlled by a gate and protected by a screen as in the case of the service entrance.

The substructure is surmounted by a superstructure of steel and concrete, housing and protecting the machinery for operating the gates and handling the screens. The southerly end of the superstructure may be seen in the photograph on page E-36. The steel frame-work of the superstructure is extended above the roof to form one of the first of the transmission towers.

To face page E-41.

No. E-22

Photograph showing

Detail of Junction of North End of Screen House Breast-Wall

with Rock Side of Forebay.

looking northerly.

Taken November 17th, 1921.

COPY

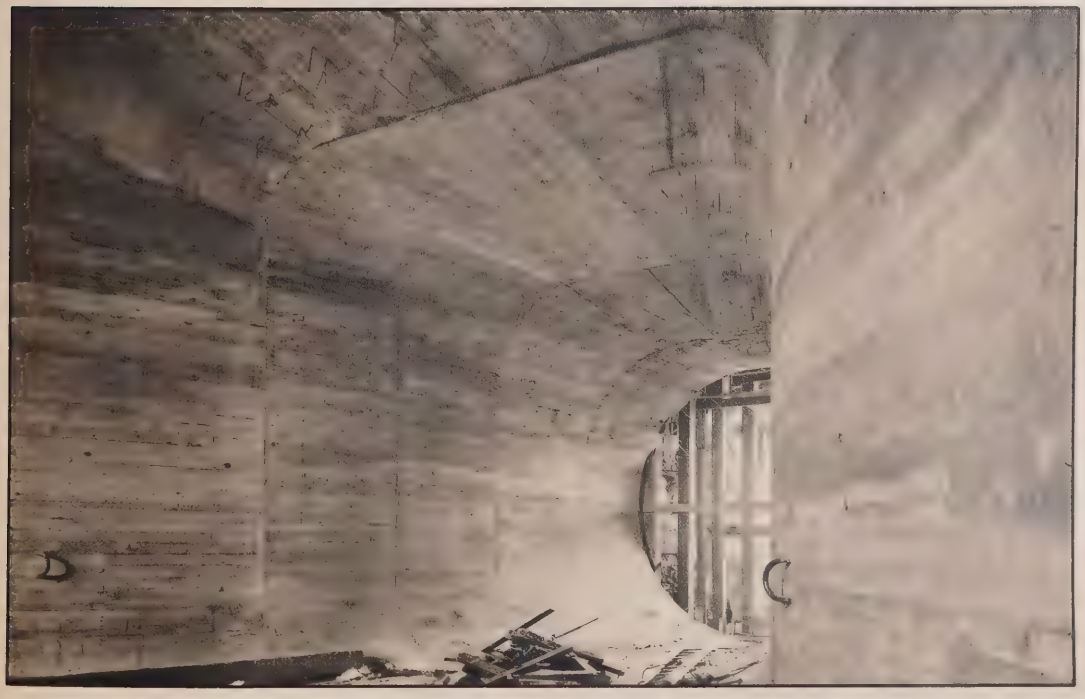
No. E-23

Photograph showing

Detail of Part of a Penstock Bell-Mouth Entrance at Screen House.

looking towards Penstock.

Taken July 22nd, 1921.


D
C

At the southerly end of the Screen House is located the administration building for the Power House, connected therewith by an elevator operating in a shaft which is joined with the plant by a tunnel, both shaft and tunnel being excavated in the solid rock. The construction of a similarly equipped building is contemplated at the northerly end of the Screen House.

The space between the Screen House and the escarpment will be finished to provide accommodation for vehicular traffic, electric railway traffic and pedestrians. A sidewalk twelve feet wide, protected by a railing, will have its outer edge 105 feet from the centre of the Screen House, thus projecting somewhat beyond the edge of the cliff. Next to the sidewalk there will be two electric railway tracks, and between the tracks and the Screen House a finished roadway 22 feet wide.

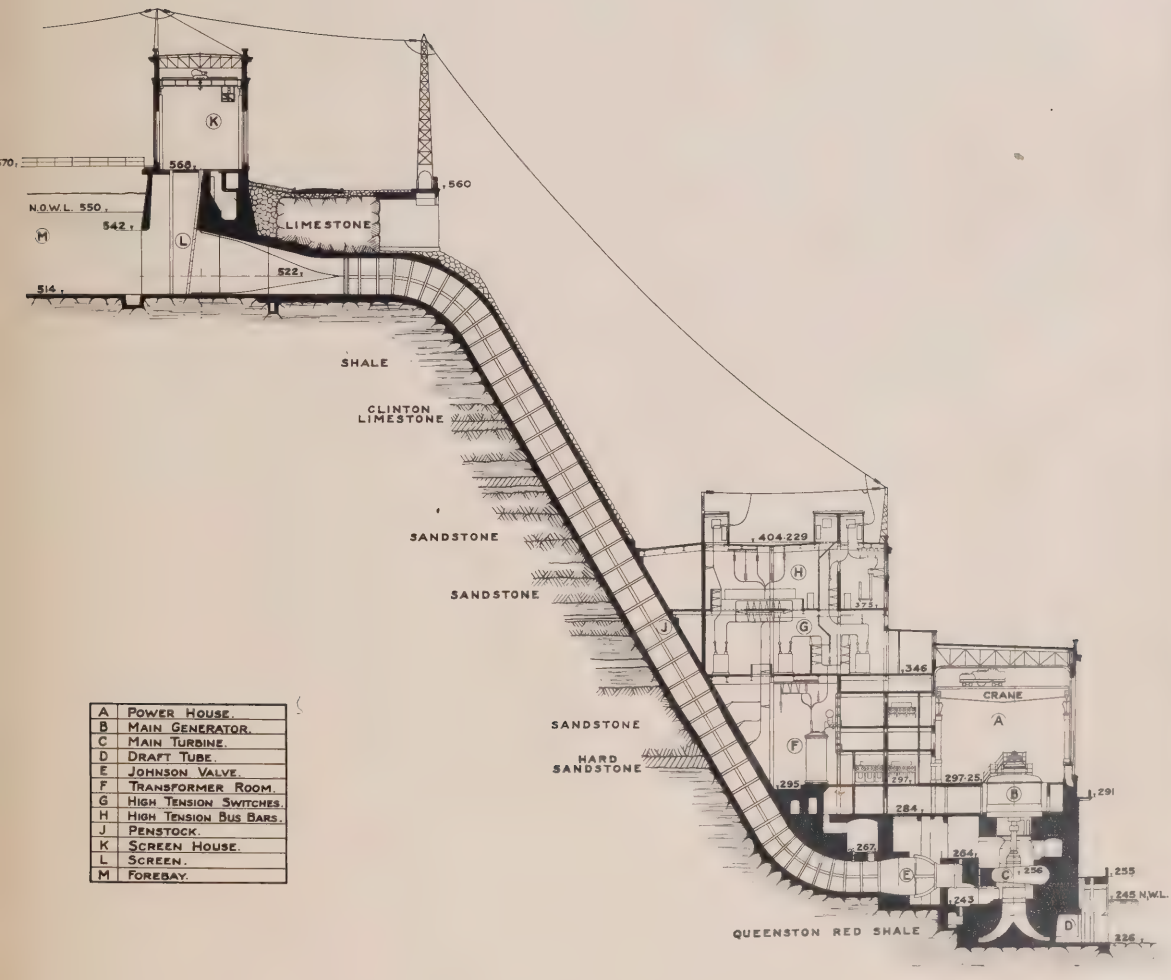
The Penstocks.

There are ten penstocks provided for in the ultimate development, in addition to the ice chute. The ice chute is at the southerly end of the series. Next to it and 24 ft. 10 ins. therefrom, measured centre to centre, is the service penstock. Following in order are the main unit penstocks, 50 feet centre to centre, No. 1 main unit penstock, the most southerly one, being 34 ft. 4 ins., centre to centre, from the service penstock. The ice chute is formed in reinforced concrete with an internal diameter of 10 feet. For the main units the penstock is of rivetted steel plate encased in concrete, and it leads from the concrete lined tunnel connecting with the downstream side of

the Screen House through tunnel excavation in the rock to the edge of the escarpment. Curving down with a bend over the escarpment in a trench excavated in the rock, on a slope of about 60 degrees with the horizontal, the penstock has a second bend at the level of the centre of the turbine, and is finally joined by a short horizontal portion to a Johnson valve adjacent to the turbine. The horizontal distance from the centre line of the Screen House to the axis of the main units is 356 ft. 6 ins., while the vertical distance from the centre of the upper part of the penstock to the centre of the lower part is 246 feet. The diameter of the upper two-thirds of the length of the main unit penstocks is 16 feet, which is reduced by means of a taper section to 14 feet for the balance of the length. The thickness of the plating varies from one-half inch at the top section to one and one-quarter inches at the lowest section. All joints are made with butt straps, thus producing a smooth interior excepting for the longitudinal butt straps and the rivet heads. Water-tightness is obtained by caulking the longitudinal seams, and welding the circumferential, always working from the inside. The bend near the upper end, as well as that near the lower, is anchored in a mass of concrete. The minimum thickness of the concrete encasing the remainder of the pipe is 2 feet.

The large Johnson valve referred to above, has an outlet 10 feet in diameter, and connects to the turbine casing by a number of sections of flanged cylindrical steel castings. A hand lever on a three-way plug valve controls a number of pistons under penstock pressure, and they in turn control three eight-inch Johnson valves which actuate the large valve.

The penstock of the service units follows the same alignment as those for



A	Power House.
B	Main Generator.
C	Main Turbine.
D	Draft Tube.
E	Johnson Valve.
F	Transformer Room.
G	High Tension Switches.
H	High Tension Bus Bars.
J	Penstock.
K	Screen House.
L	Screen.
M	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- y291

Scale of Feet

Hydro-Electric Inquiry Commission.
W. D. Gregory — Chairman.

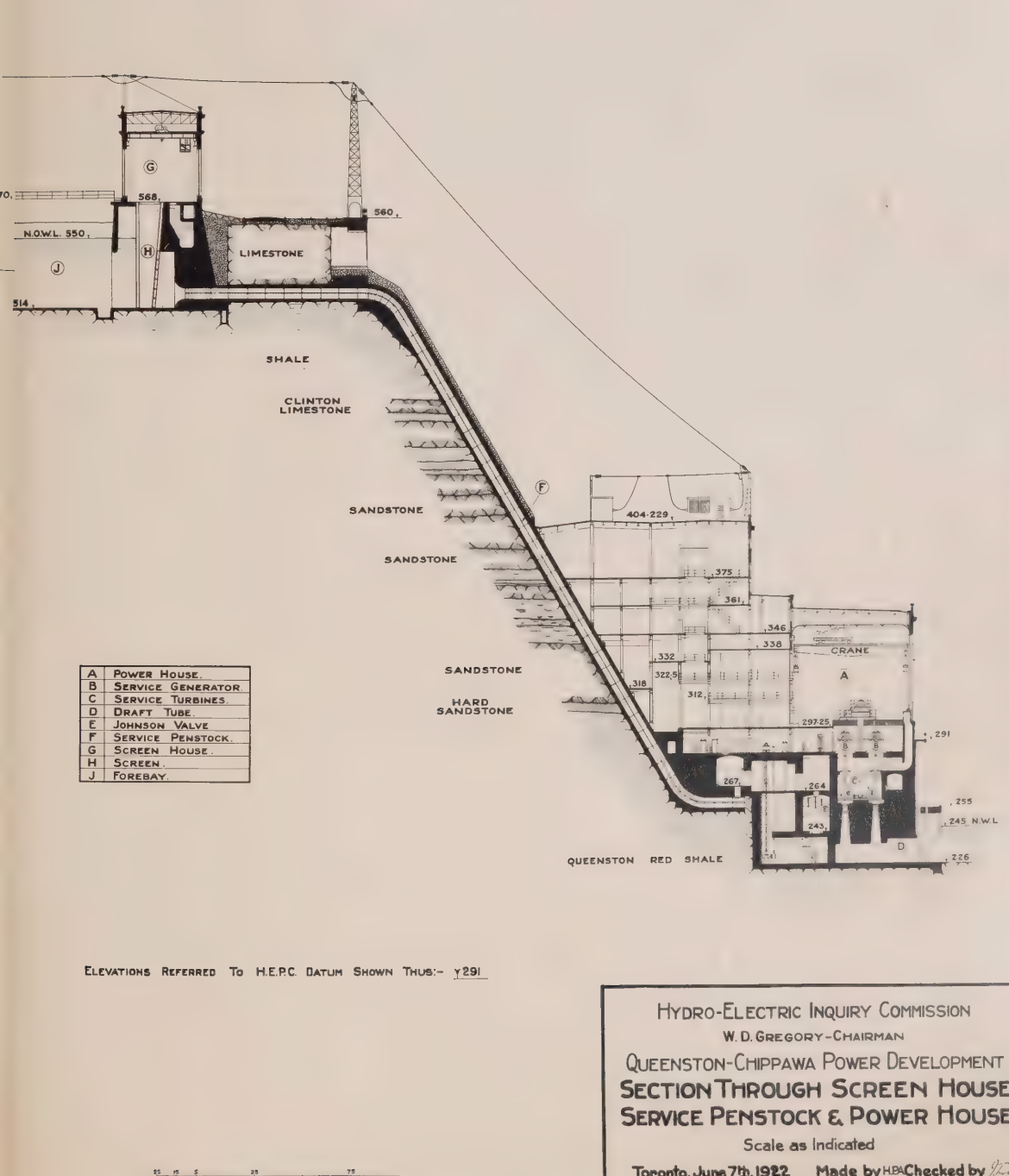
Queenston-Chippawa Power Development.

Section Through Screen House, Main Penstock And Power House

Scale as Indicated

Toronto. May 25th 1922 Made by H.P.A. Checked by J.F.

Walter. J. Francis, C.E.,
Consulting Engineer.



A	Power House.
B	Service Generator.
C	Service Turbines.
D	Draft Tube.
E	Johnson Valve.
F	Service Penstock.
G	Screen House.
H	Screen.
J	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- 291

Scale of Feet

Hydro-Electric Inquiry Commission
W. D. Gregory - Chairman

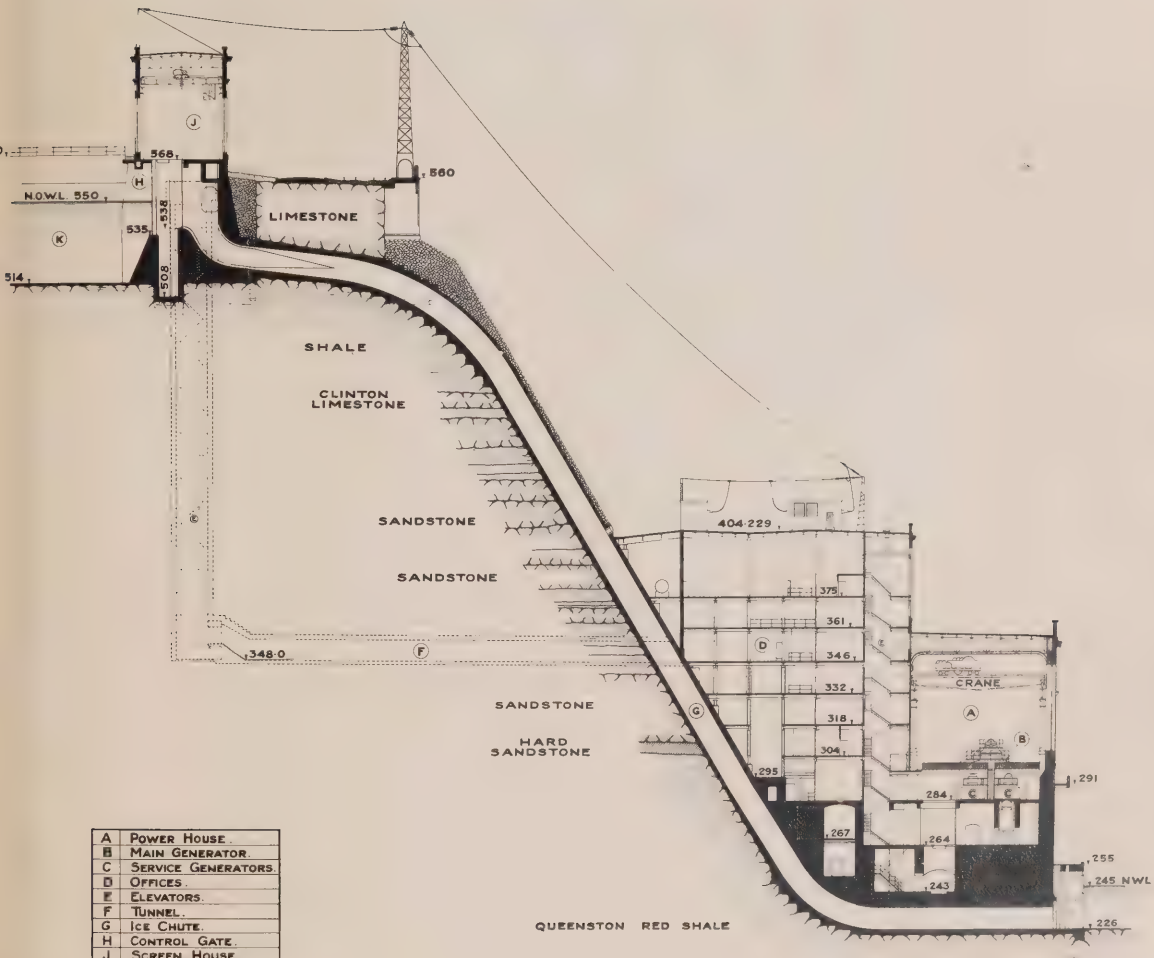
Queenston-Chippawa Power Development

Section Through Screen House Service Penstock & Power House

Scale as Indicated

Toronto, June 7th. 1922 Made by H.P.A. Checked by W.J.F.

Walter J. Francis, C.E.,
Consulting Engineer



A	Power House.
B	Main Generator.
C	Service Generators.
D	Offices.
E	Elevators.
F	Tunnel.
G	Ice Chute.
H	Control Gate.
J	Screen House.
K	Forebay.

Elevations Referred To H.E.P.C. Datum Shown Thus:- 291

Scale of Feet.

Hydro-Electric Inquiry Commission

W. D. Gregory - Chairman

Queenston-Chippawa Power Development

Section Through Screen House Ice Chute and Power House

Scale as Indicated

Toronto, June 15th 1922. Made by H.P.A. Checked by J.L.H.

Walter J. Francis, C.E.,

Consulting Engineer

To face page E-46.

No. E-24

Photograph showing

Construction of Ice Chute and Service Penstock.

looking from roof of Power House.

Taken January 6th, 1922.

To face page E-49.

No. E-25

Photograph showing

Construction of Main Penstocks.

looking from roof of Power House.

Taken January 6th, 1922.

To face page E-60.

No. E-27

Photograph showing

Johnson Valve at Lower End of Main Penstock.

looking from Penstock.

Taken February 4th, 1922.

COPY

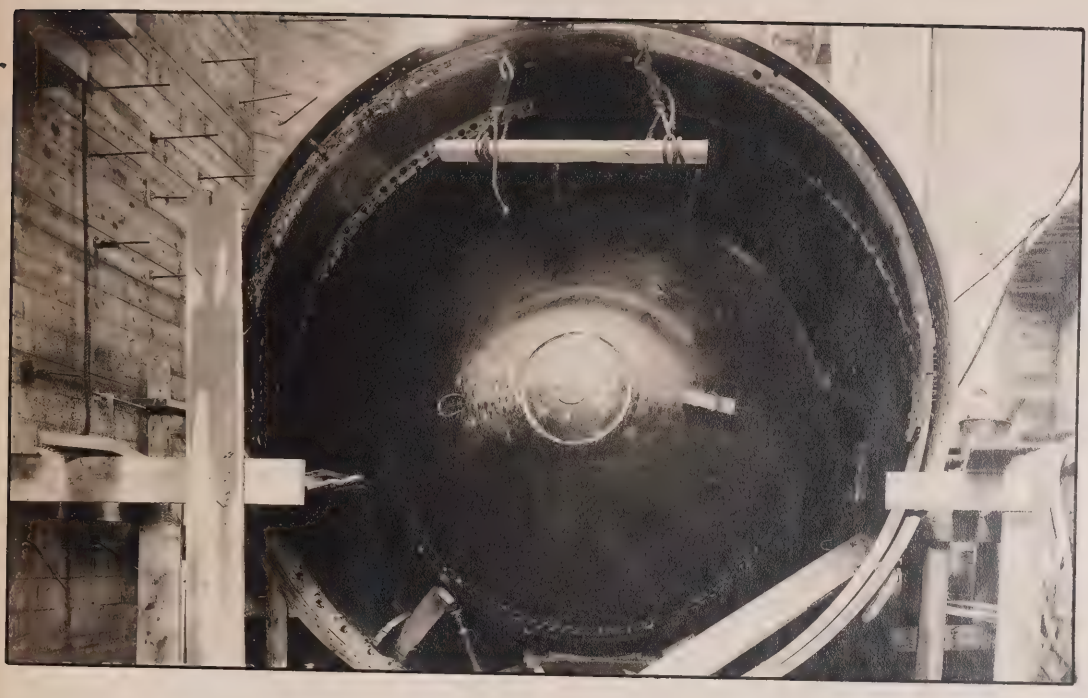
No. E-26

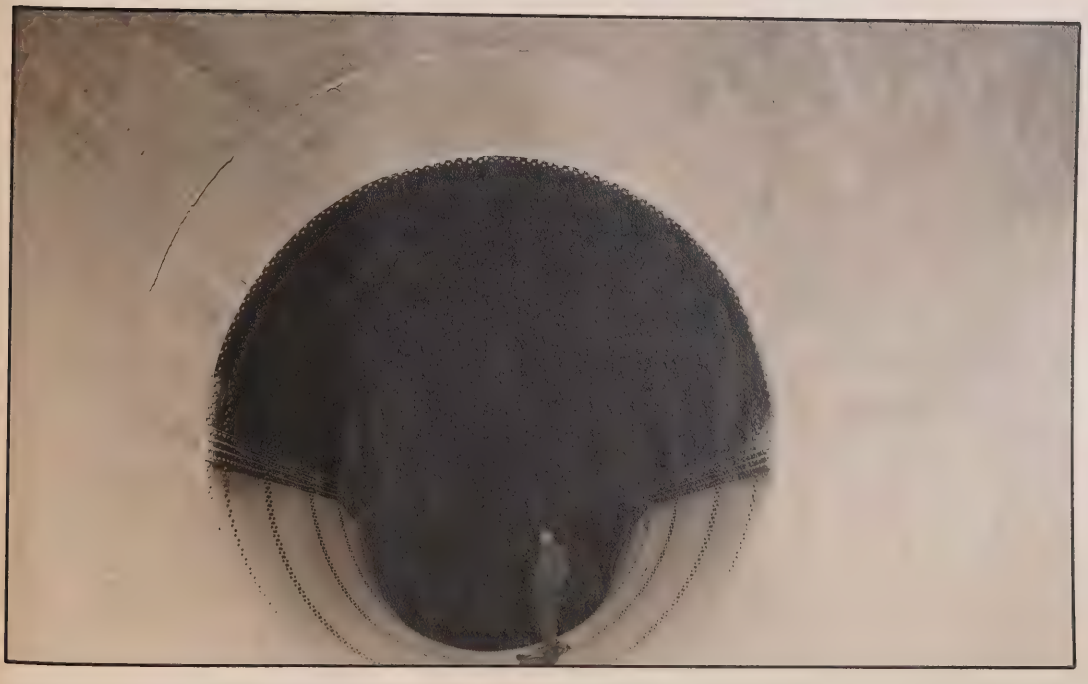
Photograph showing

Lower End of Main Penstock.

looking into Penstock.

Taken April 7th, 1922.





To face page E-51.

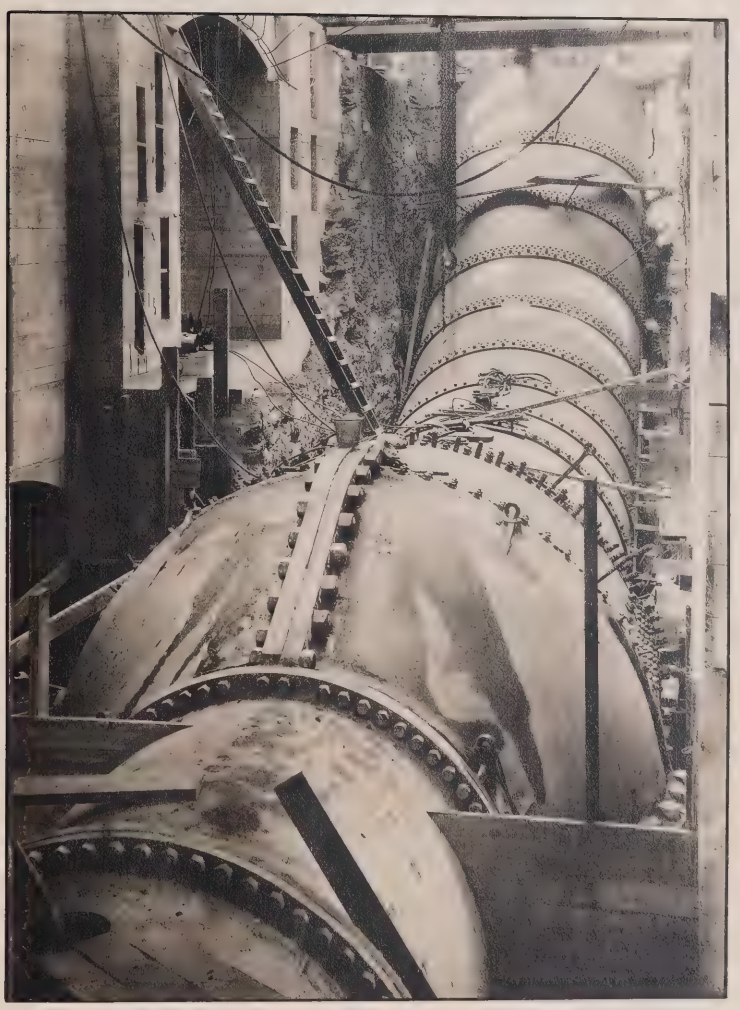
No. E-28

Photograph showing

Lower End of Main Steam and Feed of Johnson Valve.

looking towards Pedk.

Taken June 18th, 21.



MR. J. ALLAN ROSS.

To face page E-82.

No. E-29

Photograph showing

Penstock Excavation and Character of Rock at Summit of Escarpment.

looking from roof of Power House.

Taken April 21st, 1922.

The Power House.

The Building.

The Power House, located at the water's edge of the Niagara River, directly opposite and parallel to the Screen House, is about 660 feet in length. The site is shown on photograph No. E-50, included herewith as page E-54, the picture indicating the conditions just after the commencement of the excavation. It consists essentially of a substructure and a superstructure. The substructure, which is primarily the containing structure of the main units, has its top surface at Elevation 297.25, while the bottom is founded in the solid rock which has been excavated down to about Elevation 224 for that purpose. At the present time the Power House will be completed from the southerly end far enough to contain main unit No. 5, the units being numbered in order from south to north, a length of about 340 feet. Within the portion now under construction are contained the two service units, five main units and the auxiliary plant, as well as the necessary electrical connecting parts.

The settings of the five main units are substantially alike, except that the draft tube of No. 1 is of the usual curved type, somewhat modified, while those for units Nos. 2, 3, 4 and 5 are of the Moody spreading type. The formwork for draft tube No. 1 is shown on the upper photograph, No. E-51, on page E-55, while the lower photograph, No. E-52, on the same page shows the finished concrete work thereof. The Moody draft tube for the other main units is well illustrated in the next three photographs, the first of which, No. E-53,

To face page E-54.

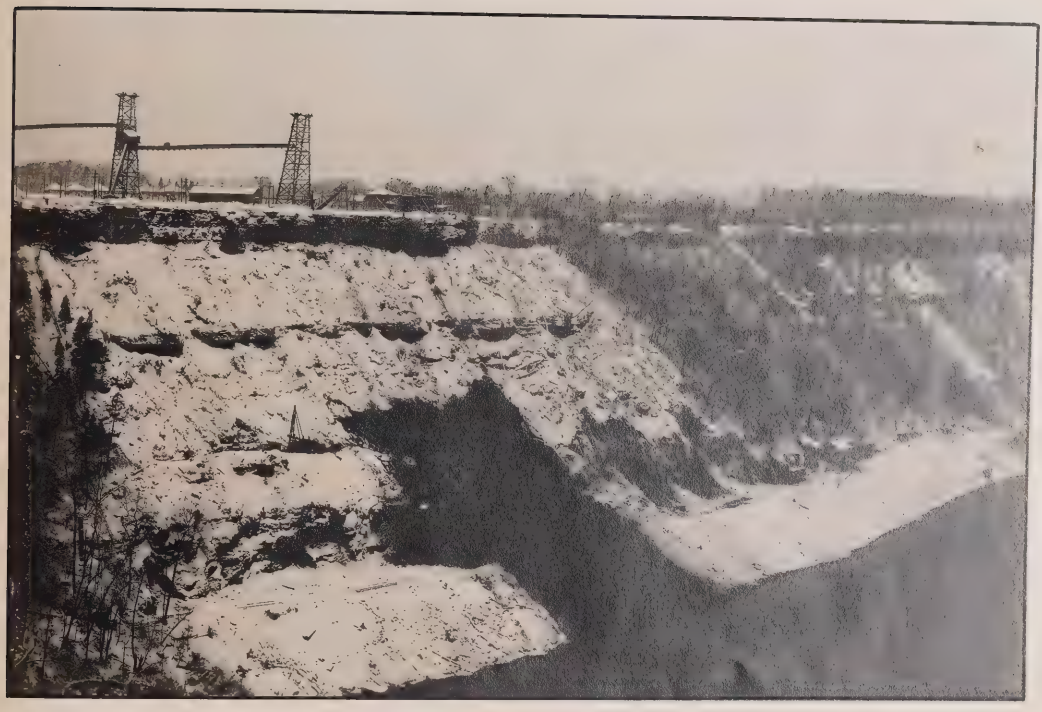
No. E-20

Photograph showing

Power House Site At Commencement of Excavation.

looking north-easterly.

Taken December 7th, 1919.



To face page E-55.

No. E-51

Photograph showing

Formwork for Draft Tube No. 1.

looking southerly.

Taken December 12th, 1920.

No. E-52

Photograph showing

Interior of Draft Tube No. 1.

after removal of forms.

Taken March 22nd, 1921.

MR. J. ALLAN ROSS.

To face page E-56.

No. E-55

Photograph showing

Formwork for "Moody" Draft Tube No. 2.

looking westerly.

Taken February 1st, 1921.

No. E-54

Photograph showing

Cone for "Moody" Draft Tube No. 2.

after removal of forms.

Taken July 8th, 1921.

To face page E-57.

No. E-56

Photograph showing

Completed Side Passage of "Moody" Draft Tube No. 3,

looking towards rear.

Taken December 7th, 1921.

on page E-56, shows the finished formwork; the second, No. E-54, on the same page, a detail of the draft tube cone; while the third, No. E-55, on page E-57, gives a detail view of the finished concrete of one of the side passages.

The substructure forms the anchorage at the bottom of all the penstocks, and is also arranged as the foundation of all the turbines and the electrical machines, and to provide access thereto by ardways, tunnels and passages. Briefly, there are five principal levels in the substructure: Elevation 226, the floor of the tail race; Elevation 245, giving access to the under side of the main turbines; Elevation 264, giving access to the gate mechanism of the main turbines; Elevation 284, being the base of the service units and of the main units; and Elevation 297.25, the main operating floor, or top of the substructure, on which are also located the low tension switching apparatus and the high tension transformers. Along the river side, the substructure extends in the form of piers arched over with a floor, the top of which is at Elevation 255, constituting a railway passage, and in the southerly end is a large doorway with the sill at Elevation 284 whereby the railway cars may be taken into the Power House. In addition to the principal features, many details such as drainage, filtration, assembly and repairs have been provided for. The substructure is of concrete throughout, reinforced with steel where special stresses occur. With the exception of the end doorway, which is provided with stop-log checks, there are no openings in the exterior of the Power House below Elevation 300, so that flooding of the plant by abnormal rise of the river may be avoided, and the walls are designed to resist a hydrostatic head up to that elevation.

The succeeding series of photographs, ten in number, illustrate various

stages of progress of the Power House, and, particularly of the substructure. The first six photographs were taken from the top of the cliff looking almost directly down on the structure, and they are numbered E-36 to E-41, and are contained on page E-60, E-61 and E-62 hereof. A study of them will reveal a great many of the salient features already described. The seventh of the series, being No. E-42, page E-63 hereof, was taken from near the same point on the top of the cliff, but looking up the gorge. It shows the relation of part of the completed substructure to the side of the cliff, near the top of which the upper part of penstock No. 1 may be seen in course of erection. The eighth photograph, being E-43 on page E-64 hereof, was taken from the east shore of the river near the bottom of the gorge, looking diagonally down-stream at the Power House; while the ninth, E-44 on the same page, was also taken from the low level on the opposite shore, but looking directly at the Power House. The last of the series, being E-45, on page E-65 hereof, gives a detail of the water side of the substructure and the arches over the draft tube passages.

The superstructure is built of steel, concrete, reinforced concrete and terra cotta finished in Portland cement. It covers the substructure, and en-closes the whole of the space up to the face of the cliff to the top of the principal roof which is at Elevation 404. The portion over the main units rises in one clear storey, and contains two cranes each with a lifting capacity of 150 tons, so arranged as to be able to handle 300 tons when working to-gether. Within the larger portion of the northerly end of the superstructure are the high tension transformers, switches and bus-bars, located generally on

To face page E-60.

No. E-56

Photograph showing

Construction of Power House.

looking from top of cliff.

Taken January 8th, 1921.

No. E-57

Photograph showing

Construction of Power House.

looking from top of cliff.

Taken March 1st, 1921.

To face page E-61.

No. E-58

Photograph showing

Construction of Power House,

looking from top of cliff.

Taken March 22nd, 1921.

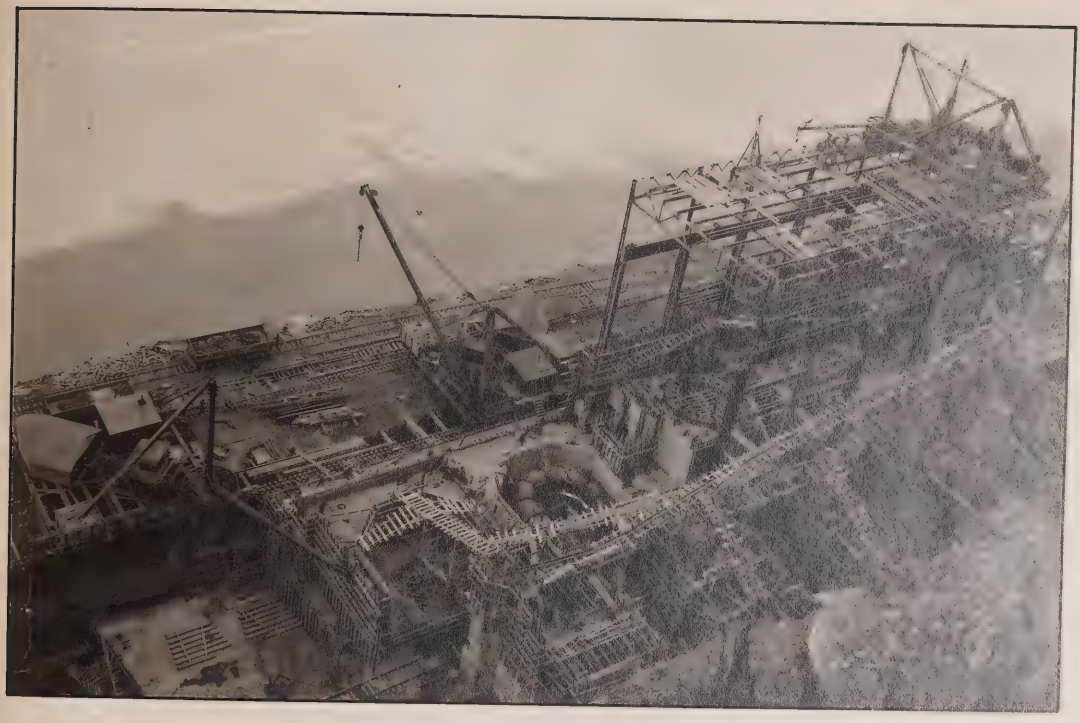
No. E-59

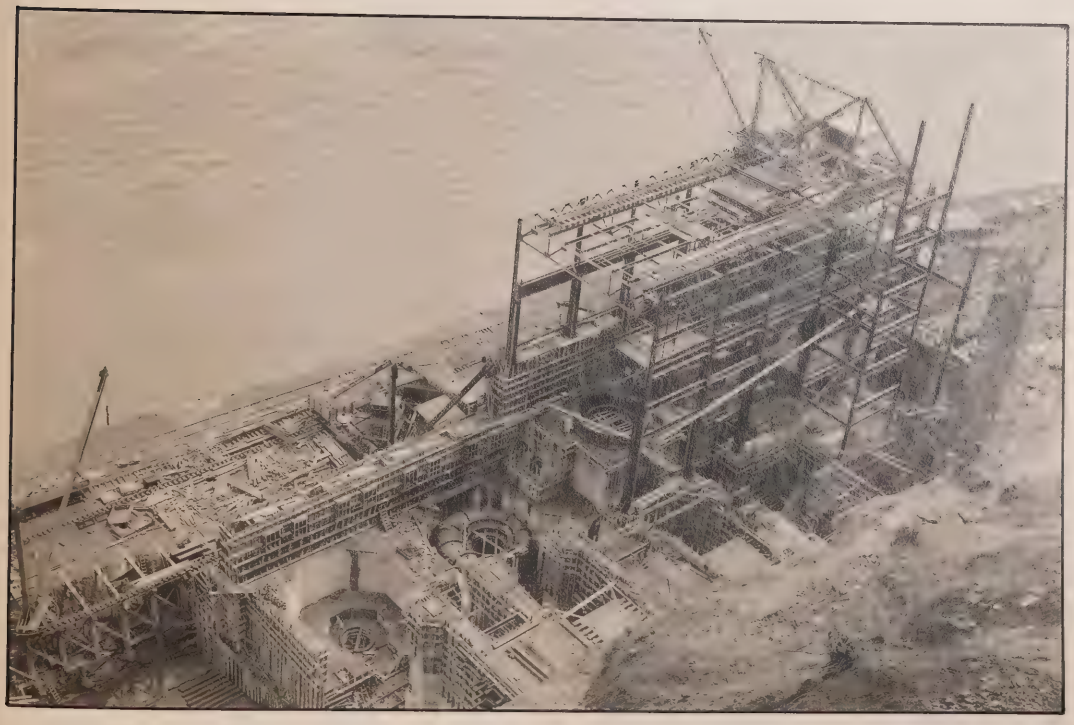
Photograph showing

Construction of Power House,

looking from top of cliff.

Taken April 8th, 1921.





To face page E-62.

No. E-60

Photograph showing

Construction of Power House.

looking from top of cliff.

Taken July 8th, 1921.

COPY

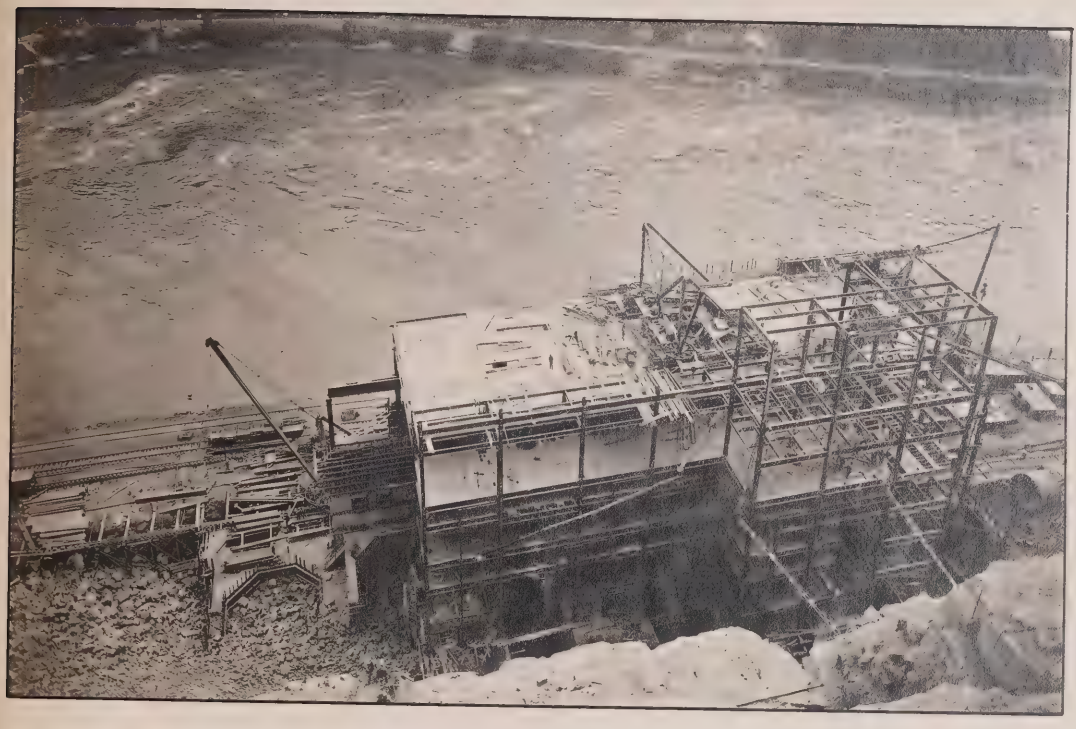
No. E-61

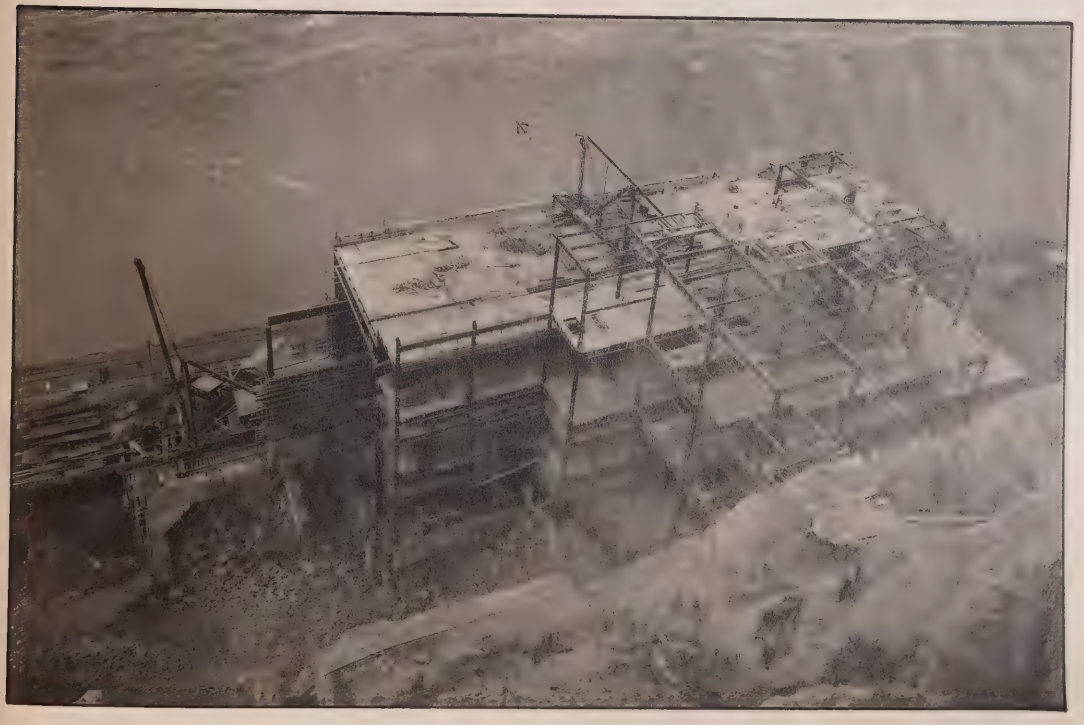
Photograph showing

Construction of Power House.

looking from top of cliff.

Taken October 3rd, 1921.





To face page E-43.

No. E-42

Photograph showing
Construction of Power House and Penstocks.
looking up Niagara River.

Taken September 1st, 1921.

To face page E-64.

No. E-43

Photograph showing

Construction of Power House.

looking from opposite shore.

Taken July 20th, 1921.

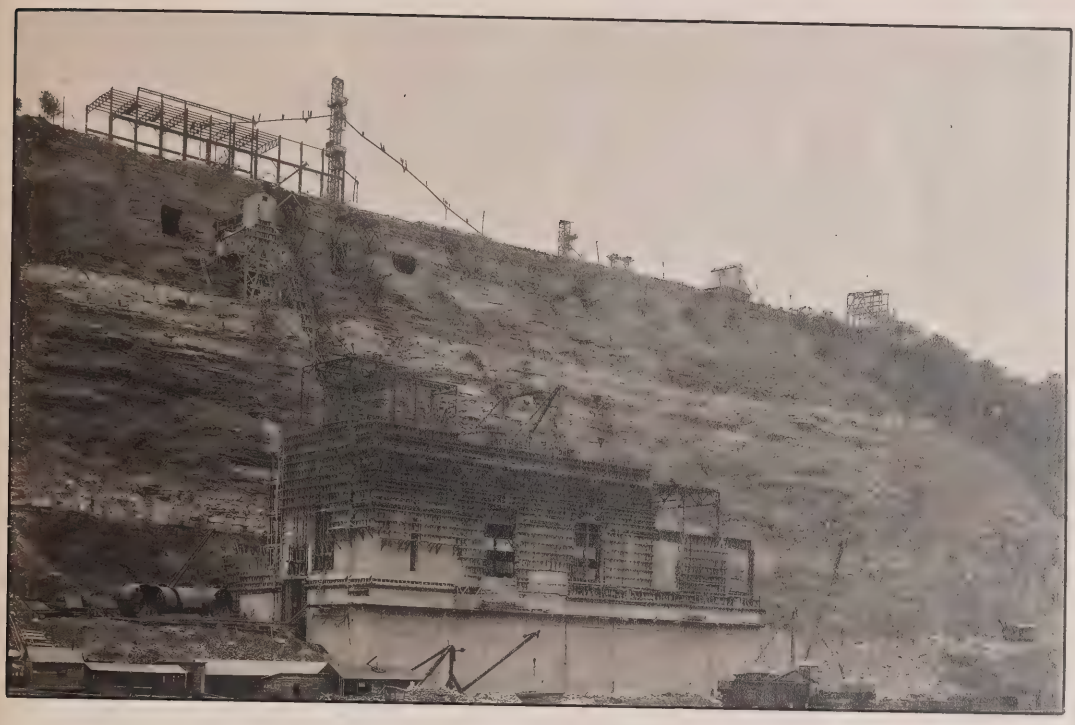
No. E-44

Photograph showing

Exterior of South End of Power House.

from opposite shore.

Taken September 2nd, 1921.



MR. J. ALLAN ROSS.

To face page E-65.

No. E-65

Photograph showing

Detail of River Side of Power House Substructure.

looking towards draft tubes.

Taken December 28th, 1921.

To face page B-66.

No. B-46

Photograph showing

Power House, Penstocks, Forebay House and Canal.

looking westerly from aeroplane.

Taken September 23rd, 1921.

the three principal floor levels, Elevation 297, Elevation 345, and Elevation 375 respectively, while on the roof are pent houses from which the high tension lines lead to towers and on up over the Screen House. In the southerly part of the superstructure, divided generally into seven floors, are offices, operators' quarters, store-rooms, and so forth, as well as an elevator giving access to the tunnel whereby the offices in the administration building at the southerly end of the Screen House are ultimately reached.

The aeroplane photograph, No. E-66, included herewith as page E-66, shows the Power House in relation to the river, the cliff, the Screen House, the Forebay, and the Canal, as well as the general arrangement of the construction plant, the camp, the sidings and the roads.

Turbines.

The main unit turbines, Nos. 1 to 5 inclusive, are of the vertical shaft, spiral case, single runner, Francis type, operating at 187-1/2 revolutions per minute, with a nominal brake horse power of 58,000 under 305 ft. head. The diameter of the runner is 135 inches, and the diameter of the shaft 30 inches. The scroll cases are made of steel castings, the details of which may be seen by reference to the photograph No. E-47 on page E-68 hereof, and to photograph No. E-48 on page E-69, the former being a view of the case of No. 2, and the latter of No. 4. The turbines for unit No. 1 and unit No. 2 were manufactured by the Wellman-Seaver-Morgan Co., while the turbines for the other three units are being made by the Wm. Cramp & Sons Ship & Engine Bldg. Co., I. P. Morris Department. The governor system for the main units uses

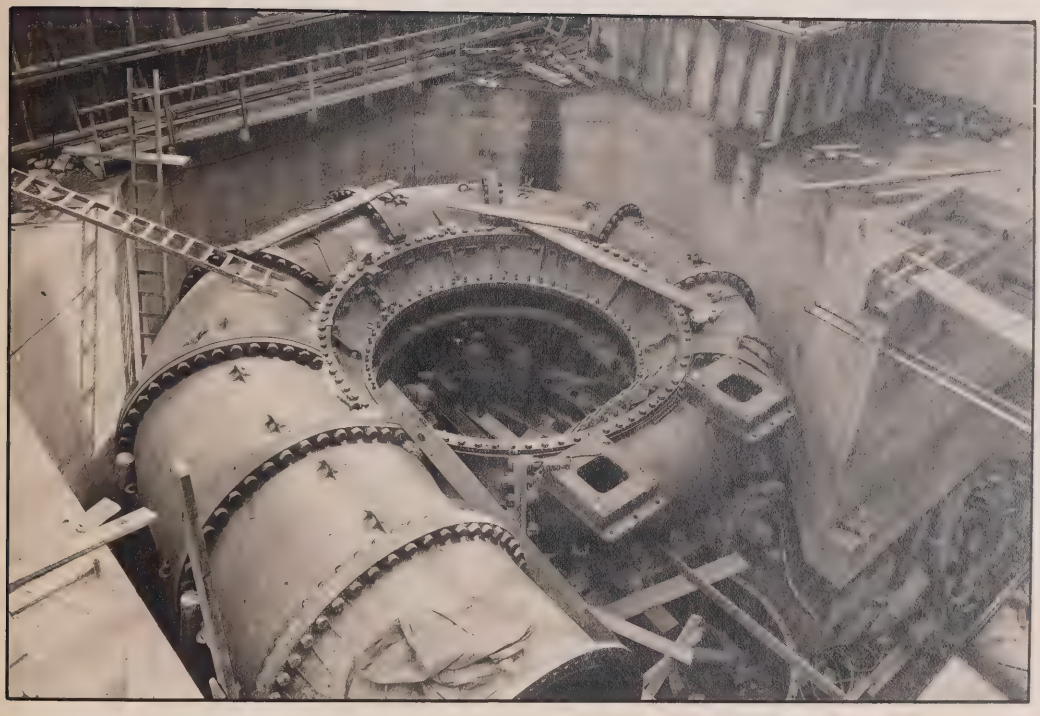
To face page E-68.

No. E-47

Photograph showing

Barrell Case of No. 3 Turbine during Erection.

Taken April 6th, 1921.



To face page E-69.

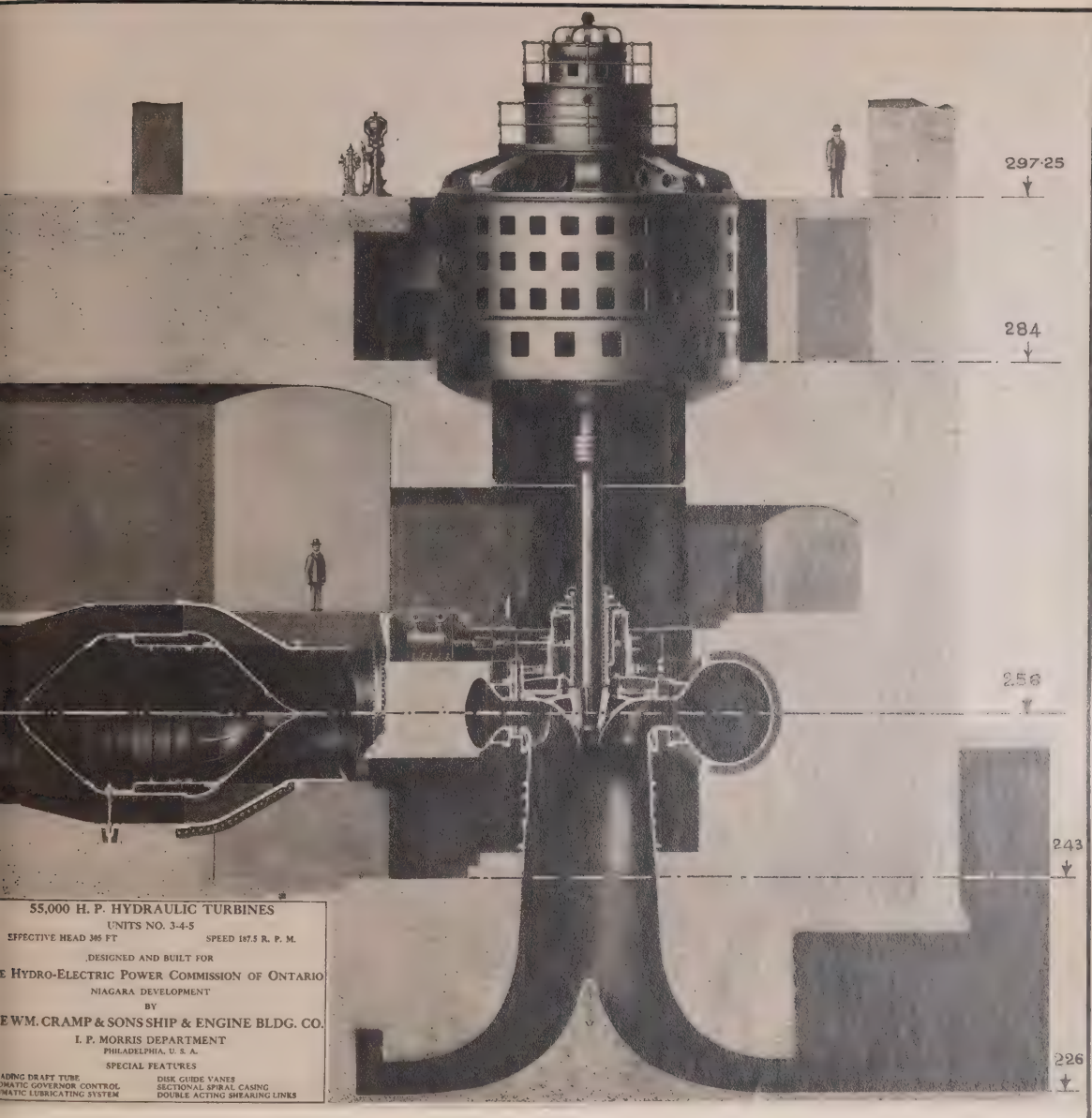
No. E-68

Photograph showing

Erection of No. 4 Turbine Barrell Case.

looking north-westerly.

Taken April 21st, 1922.



55,000 H. P. HYDRAULIC TURBINES
UNITS NO. 3-4-5
EFFECTIVE HEAD 305 FT SPEED 187.5 R. P. M.
DESIGNED AND BUILT FOR
E HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
NIAGARA DEVELOPMENT
BY
E WM. CRAMP & SONS SHIP & ENGINE BLDG. CO.
I. P. MORRIS DEPARTMENT
PHILADELPHIA, U. S. A.
SPECIAL FEATURES
ADING DRAFT TUBE — DISK GUIDE VANES
OMATIC GOVERNOR CONTROL — SECTIONAL SPIRAL CASING
OMATIC LUBRICATING SYSTEM — DOUBLE ACTING SHEARING LINKS

ELEVATIONS REFERRED TO H.E.P.C. DATUM SHOWN THUS.— 256

8 6 4 2 0 5 10 20 30 40
Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY—CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
MANUFACTURERS' SECTION OF MAIN UNIT No 4
Scale as Indicated
Toronto, July 5th 1922
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

filtered water containing one per cent. of soluble oil.

One of the latter turbines is shown in complete cross-section in the photographic reproduction of a wash drawing, included herewith as page E-70. This drawing shows the relation of all the principal parts of a main unit.

Generators.

The five main generators are each rated at 45,000 kv.a., 80% power factor, 12,000 volts, three-phase, 25 cycles at 187-1/2 revolutions per minute. They are of the vertical type, with direct-connected, shunt-field commutating-pole, 250-volt, 150-k.w. exciter. The generators for units Nos. 1, 2 and 3, manufactured by the Canadian Westinghouse Company, have the rotor made with a steel cast spider and a laminated, built-up sheet steel rim; upper and lower bearing brackets of cast iron, provided with the Kingsbury thrust bearing; while the stator is divided vertically into four equal sections. The other two generators, Nos. 4 and 5, manufactured by the Canadian General Electric Co., have the rotor made up of seven steel cast wheels bolted together, the two outer acting only as fly wheels; upper and lower brackets of steel castings, provided with a spring-supported type of thrust bearing; while the stator is divided vertically into three equal sections. The over-all diameter of the main generators is 25 feet, the diameter of the rotor over the pole faces being approximately 18 feet.

The upper photograph No. E-49, on page E-72 hereof, shows the top of generator No. 2, together with the control pedestal and the governor, while the lower picture, No. E-50, on the same page, shows the top of generator No. 1.

To face page B-72.

No. B-49

Photograph showing

Top of No. 2 Generator with Control Pedestal and Governor,

looking easterly.

Taken February 23rd, 1922.

COPY

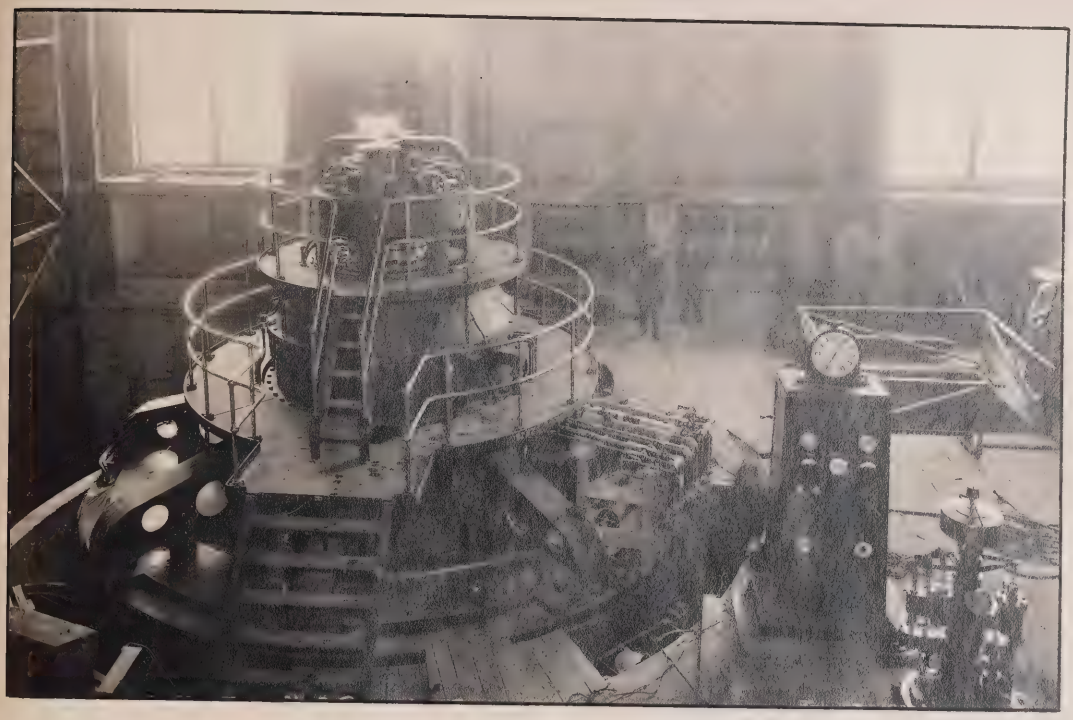
No. B-50

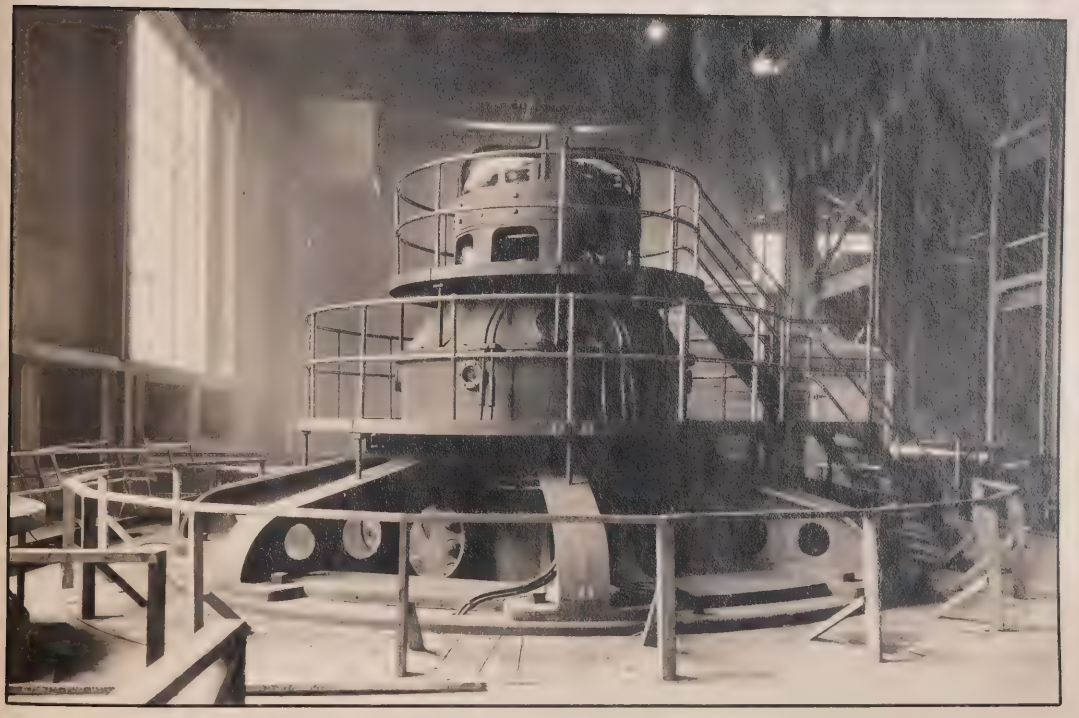
Photograph showing

Top of Generator No. 1,

looking southerly.

Taken January 6th, 1922.





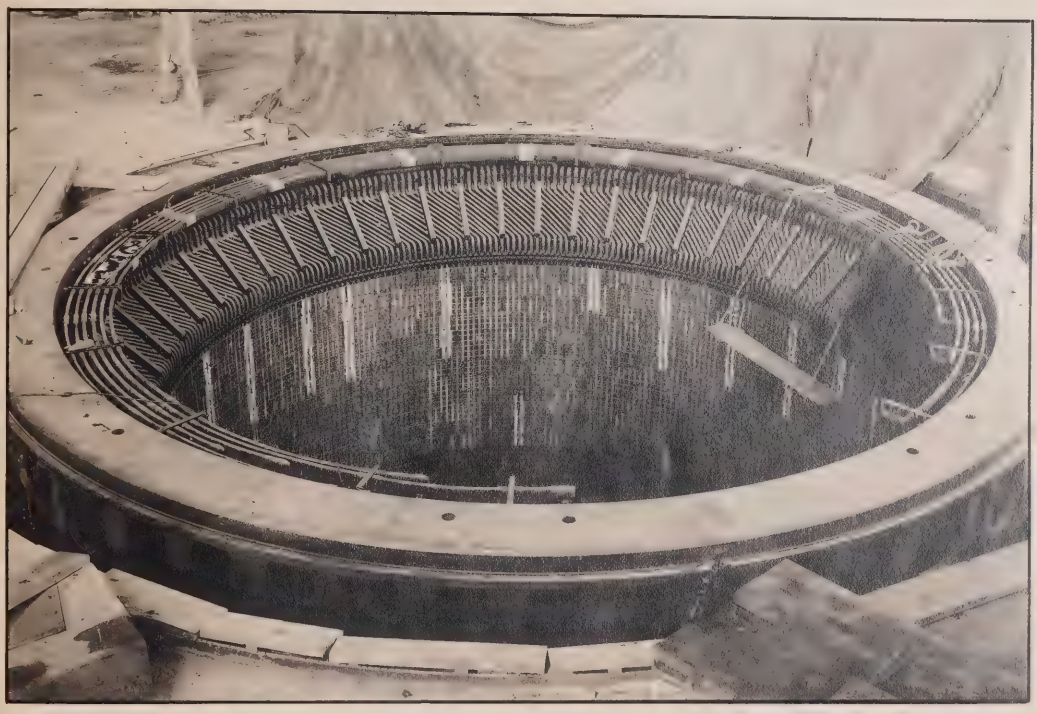
MR. J. ALLAN ROSS.

To face page E-76.

No. E-51

Photograph showing
Stator of No. 1 Generator.
during erection.

Taken September 10th, 1921.

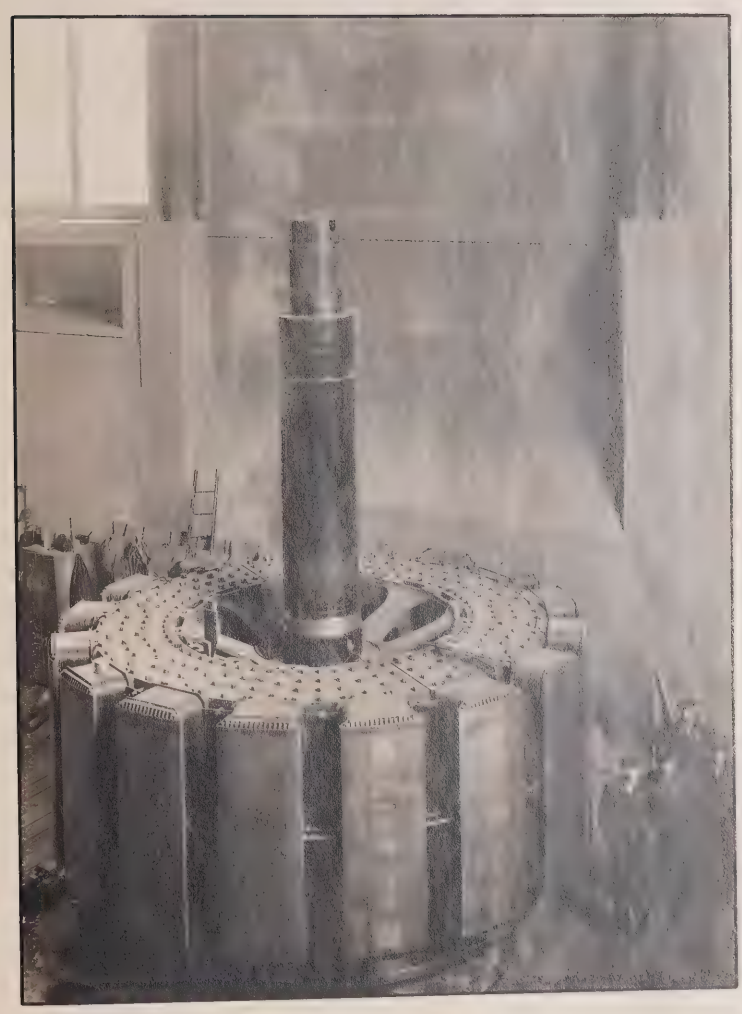


To face page M-74.

No. M-52

Photograph showing
Rotor [illegible] Generator,
ready for installation.

Taken April 4th, 1922.



Photograph No. E-51, included herewith as page E-73, shows the stator of generator No. 1 in place, while photograph No. E-52, being page E-74 hereof, shows the rotor of No. 5 complete. Reference may be made again to the photograph of the wash drawing included as page E-70 hereof.

Service Plant.

The power for the service plant used for pumping, ventilating, lighting and other similar purposes, is derived from two turbines supplied from the service penstock already described. The turbines are rated at 2,600 horse power each at 500 revolutions under 305 feet head, and are of the single runner, vertical-shaft type with cast iron scroll cases. The generators are each rated at 2,200 kv.a., 2,300 volts, 25 cycles at 500 revolutions per minute. A view of one of the service generators with its exciter is given on photograph No. E-55, included herewith as page E-76. The governors use oil and the governor pumps are independent of the main governor system.

Auxiliary Plant.

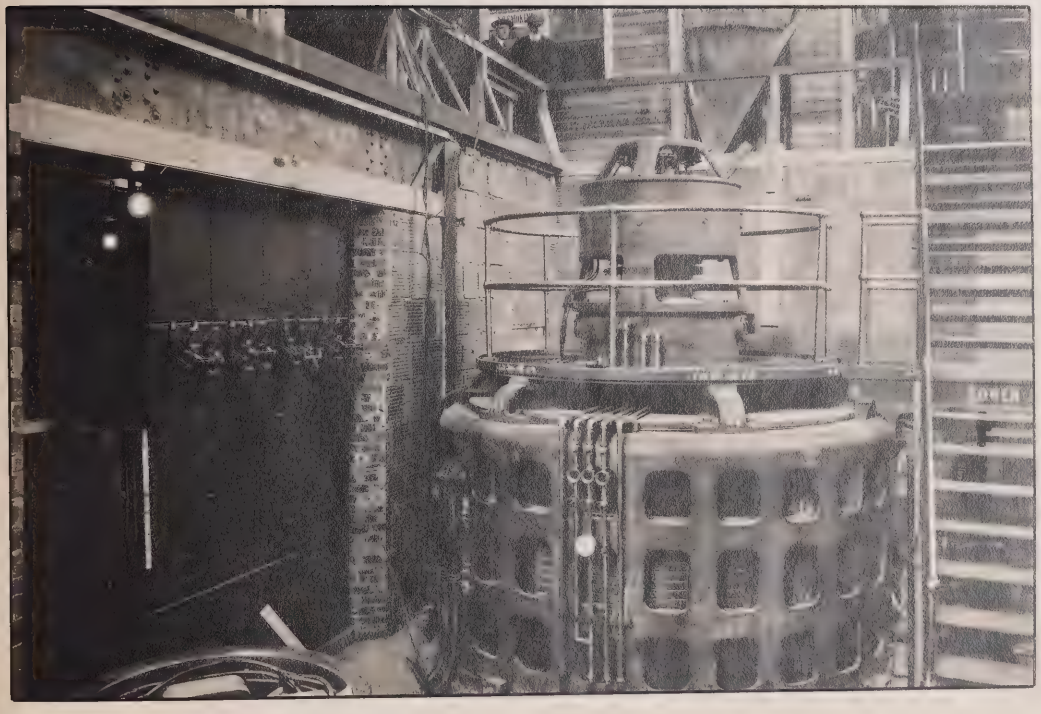
The auxiliary source of excitation of the main units consists of a motor-generator set made up of 250-volt, 150 kw. shunt-wound, direct current generator, with commutating poles designed to carry the excitation of any one of the generators. In the completed station it is contemplated that there will be additional sets, each acting as a spare exciter for a group of machines. The motor-generator sets are driven from the service units.

To face page B-76.

No. B-83

Photograph showing
Service Unit "A", in Operation,
looking northerly.

Yukon February 1st, 1922.



Electrical Equipment.

The electrical equipment consists generally of the low-tension switching system, the transformers and the high tension switching system leading to the transmission lines. The apparatus and main connections of each unit are divided into the following groups:

Main generator,
Main 12,000 volt bus,
Auxiliary 12,000 volt bus (when installed),
12,000 volt connections of transformer,
Transformer bank of three transformers,
110,000 volt connections of transformer,
110,000 volt busses.

The installation includes the necessary circuit breakers, relay protectors, reactors and lightning arresters.

The electrical control of the station is centered in the control room situated at Elevation 561 above the generator room, over generators Nos. 4, 5 and 6. The switch controls, indicators and dummy busbars are mounted on bench board sections, arranged in the general form of an arc of a circle, while the indicating instruments are carried on vertical panels at the rear of the bench boards. Further back are the panels carrying the recording meters and the relays, placed face to face.

Accessories.

In addition to the main governor system, there are complete control pedes-

Bridges and Crossings.

Provision has been duly made for suitable bridges across the Canal at all points where necessary for the accommodation of highway or railway traffic. There are eight highway bridges and five railway crossings.

Chippawa Highway Bridge.

The Chippawa Highway Bridge is located at the crossing of the Welland River, in the Village of Chippawa by the Chippawa Highway. The new bridge is a permanent structure consisting of one 99-foot bascule span of the Strauss trunnion type, with a 75-foot approach span at each end. The piers and abutments are of concrete founded on rock. The roadway of the bridge is 24 feet wide and there is a sidewalk 2 ft. 6 ins. wide on each side.

Upon the completion of the bridge, it was taken over and operated by the Department of Railways and Canals.

Photograph No. E-65 on page E-80, shows the completed structure with the bascule span partly open.

Michigan Central Railroad Bridge: Chippawa.

At the crossing of the Welland River, in the Village of Chippawa, by the Michigan Central Railroad, a new permanent structure has been provided consisting of a 150-foot swing-span and two half-through plate-girder spans, 79 feet and 74 feet in length at the southerly end of the bridge. The girders rest on

To face page E-60.

No. E-54

Photograph showing

Michigan Central Railroad Bridge at Montrose,

looking southerly along west side.

Taken May 4th, 1922.

No. E-55

Photograph showing

Chippewa Highway Bridge,

looking northerly.

Taken May 3rd, 1921.

concrete piers and abutments founded on rock. The old swing-span, located at this point prior to the improving of the Welland River Channel, was incorporated in the new structure.

Michigan Central Railroad Bridge: Montrose.

At about Station 12, at the easterly entrance to the Canal, is located the double track crossing of the Michigan Central Railroad. The new bridge is of permanent construction consisting of four steel, deck-girder spans 75 feet in length with reinforced concrete piers and abutments. The foundations for the piers consist of steel cylinders sunk to rock and filled with concrete, while the abutments are supported on piles.

The bridge is not yet complete but it is anticipated that it will be ready for traffic by the middle of August, 1922.

Photograph No. E-64 on page E-80 shows the bridge in course of construction; in the background will be noted the temporary trestle provided for the passage of trains during the construction period.

Chippewa Creek Road Bridge.

At Station 23, the Canal is crossed by Chippewa Creek Road. A temporary trestle has been provided at this point and will be utilized during its life. The type of permanent structure by which it will be replaced has not, as yet, been determined.

Portage Road Bridge.

At Station 249, the Canal is crossed by Portage Road. The bridge which is now in course of construction consists of three 90-foot steel deck, trussed spans and one 30-foot steel deck, girder span with a reinforced concrete floor. The roadway will be 30 feet in width with a 6-foot sidewalk on each side. The piers and abutments are to be of concrete.

It is expected that the structure will be ready for traffic by November, 1922.

Niagara, St. Catharines and Toronto Railway Bridge.

The Niagara, St. Catharines and Toronto Railway crosses the Canal at Station 274. The permanent bridge, which has been completed except for the wing-walls, consists of a reinforced concrete, earth-filled arch, 66 feet span and 25 feet rise.

Thorold Road Bridge.

The Thorold Road Bridge crosses the Canal at Station 289. A permanent structure is being provided, consisting of an 85-foot steel truss in the centre and a 46-foot steel truss at each end, all supported on concrete piers.

The construction of this bridge has not been commenced, but a contract has been let, and it is anticipated that the bridge will be completed by November 1st, 1922. The traffic is at present taken care of by a temporary structure.

Wabash Railway Arch.

A line of the Grand Trunk Railway, generally referred to as the Wabash Railway, crosses the Canal at Station 310. A reinforced concrete, earth-filled arch of 100 feet span, 25 feet rise and 32.5 feet width has been built at this location. The arch provides for a double track railway.

The photographs included herewith as page E-85, show this bridge under construction and approaching completion, while the photograph included herewith as page E-86, clearly shows the completed structure.

In the background of the latter photograph, there will be noted the temporary structure at the Thorold Road crossing, and also the crossing of the Niagara, St. Catharines and Toronto Railway.

Grand Trunk and Michigan Central Bridge.

At Station 324, the Canal is crossed by the main-line, double track of the Grand Trunk Railway, and by the single track branch of the Michigan Central Railway from Welland to Niagara-on-the-Lake. The bridge consists of a reinforced concrete, earth-filled arch of 72 feet span, 20 feet rise and 136.7 feet width.

The photograph included as page E-87 shows the completed structure.

Boulevard Bridge.

A bridge will be provided in the future, in the vicinity of the Forebay, for the Queen Victoria-Niagara Falls Park Commission Boulevard.

To face page E-65.

No. E-66

Photograph showing

Wabash Railway Bridge under Construction.

looking northerly.

Taken September 3rd, 1919.

No. E-67

Photograph showing

Wabash Railway Bridge.

looking northerly along Canal.

Taken January 3rd, 1922.

To face page E-86.

No. E-88

Photograph showing

Completed Subway Railway Bridge

with Thorold Road and N. S. C. & T. Bridges in the Background,

looking southerly along Canal.

Taken December 23rd, 1921.

To face page E-67.

No. E-69

Photograph showing

Completed Grand Trunk-Canadian Central Bridge,

looking southerly along Canal.

Taken December 23rd, 1921.

Transmission Line Crossings.

In addition to the bridges described above, there are eight high-tension power line crossings and four low-tension power line crossings. Of the eight high-tension crossings, four belong to the Ontario Power Company, one to the Toronto Power Company, two to the Canadian Niagara Power Company, and one to the Hydro-Electric Power Commission, the latter not being in operation as yet. The four low-tension lines are the property of the Ontario Power Company.

Right-of-Way.

Sufficient area of lands were purchased by the Hydro-Electric Power Commission to provide not only a right-of-way for the Canal itself, but also for disposal areas, for the Power House, for construction railways and so forth. In order to avoid "separation" damages in the case of farms, whole properties were purchased in many instances. In some of these cases, the excess lands have already been sold.

The total area of land involved in the purchases is well over 3,000 acres.

As has already been stated, the greater part of the land was either cultivated or used for fruit growing purposes.

Walter J. Francis